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Records for Personnel Work

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Presented on May 9, 1946, at the Annual Conference, St. Louis, Mo.

As an introduction to the subject of employee relations, the importance of good record keeping should be emphasized. Through the years business has developed various forms for the sorting and recording of essential information about employees, and the water company or municipal water department that does not avail itself of these technics is missing very important aids. Certain forms and record keeping are, under today's conditions, an essential of orderly personnel procedure. A few important records are:

1. The job application form, which should be properly filled out and retained as part of the employee's basic personnel record.

2. An adequate and well-designed personnel form, on which will be recorded the employee's job history, rate of pay, changes in classification, and other pertinent personnel information.

3. If there is a physical examination requirement before permanent placement, a procedure which most companies and many municipal departments have adopted, there should be a well-devised physical examination form.

4. Another must in personnel form development is the pay roll change form. This should provide for the signature of the executive recommending the pay roll change and should have the further approval of a higher official on the executive staff. It should also clearly show the character of the pay roll change. By this is meant an increase, a reclassification or change to another job, a new employee hired or a dismissal, retirement or other form of separation. If the management believes in the technic of merit rating in

order to select those who should be encouraged with increased compensation or promoted to higher rated positions, a well-conceived merit rating form is essential.

The author sincerely hopes that there are many water works men who still believe in the merit principle. The tendency of unionization is toward the leveling of all who work in any particular category to one rate of pay. Unions necessarily believe in seniority and, by the very nature of their existence, they generally object to any principle involving merit. Consequently, it is the author's sincere hope that water works men re-examine their systems of promotions and earned pay increases to determine whether they really apply the merit principle.

There are other personnel forms, but the most essential ones have been mentioned, and some copies have been illustrated in a previous paper by the author (1). Forms alone, however, do not suffice; it must be emphasized that it is important to record basic personnel information accurately. Memories are fallible and judgments are sometimes warped by prejudice, but personnel information that is written and recorded accurately will often be consulted and tend to eliminate personal prejudice and errors in judgment.

Reference

1. Niles, Philip B. Employee Progress Rating and Personnel Records. Jour. A.W.W.A., **36**: 603 (1944).

Employee Training and Rating

By Stephen C. Casteel

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Presented on May 9, 1946, at the Annual Conference, St. Louis, Mo.

THE three separate aspects of a well-formulated training program are: (1) selection and placement, (2) training new and present employees, and (3) rating of merit to measure effects of training.

Selection and Placement

When a machine is to be purchased, great care is usually exercised in designing, building and setting the equipment. After this, it is not at all uncommon to find the machine under the care and supervision of an untrained person who gropes about aimlessly, hoping that the machine will compensate for his lack of knowledge. The inconsistency of such procedure presents the obvious need for fitting the man to the job. The first requirement in the field of training is intelligent selection. The selectee for a given work assignment should have the capacity for training and possess the interest to utilize the opportunity that should be a part of every job. Selection technic is not a theoretical dream. It is not a complicated procedure, but rather an application of a reasonable dosage of "horse sense" on the part of the selector. The hit-and-miss methods so commonly used in selecting personnel are as obsolete as the ox-cart.

Each individual has certain ambitions, emotions, degrees of alertness and other characteristics that can be fitted to a specific job. This cannot be done as accurately, of course, as fitting a pin to a machine, because humans are being dealt with. The technic of interviewing should be cultivated by every person whose duty it is to employ people. There are simple aptitude tests that are useful in selecting employees; however, experience teaches us that great care must be exercised in the use of such tests. Proper tests are useful only as a means to an end, but they are not themselves the end of selection. When a position is to be filled, the employer should ascertain the requirements of the specific vacancy and visualize possible promotions from the job. This information enables the interviewer to predetermine the requirements to man the position effectively. A capable interviewer will impart to the prospective employee information concerning the requirements of the job, the company's or department's policies dealing with opportunities for promotion, insurance and pension plans, vacations, sick leaves, and so on.

When the new employee is finally selected, placement becomes important. Entering a new organization is not a simple procedure for some people. By all means it should be conveyed to the employee that he is welcome, that his services are needed and that the management is extremely desirous that he progress to the ultimate of his capacity and interest.

Training

The general method of training follows the same pattern for new and old employees, with the exception of a short period of indoctrination training for the new employee. What can be expected from a training program? An efficient worker is happier than an inefficient one. Training produces efficient workers. It gives them the feeling that they "belong," and are vital parts of the organization. A well-informed man or woman is self-confident in the assurance that he or she possesses the "know how" of the job. In addition, the benefits derived from an honest application of training technic will accrue to the company or department as well as to the employee. A great amount of dissatisfaction emanates from the workman not having the opportunity to apply his capacity and interest. Again, many a job suffers from incompetence of the incumbent when management has no intelligent plan of selecting, training or rating employees. Prior to instituting a program, a personnel survey should be made, comprising a record of the age, length of service and formal education of all employees to be included in the program. From this survey the type and scope of training desirable may be determined.

For over fifteen years the author has closely observed the results of training as applied to the water works industry at several widely separated localities. In every attempt higher efficiency has been achieved, and at the same time employee morale has been improved. This was accomplished by inspiring team work to encourage co-operative effort, and also by giving prompt recognition to individual performance.

Just consider for a moment the combustion of fuel, a very important phase of steam plant operation. Too often those in authority consider the understanding of such terms as CO_2 and fuel-air ratio to be within the scope of those in the higher positions only. The facts are that one's own knowledge of combustion serves no useful purpose unless applied, and the logical place for its application is at the equipment. If steam plant efficiency is to be improved, there should be placed before the personnel operating the equipment the opportunity to acquire a knowledge of the elements of combustion.

The author has used a course of ten lectures, supplemented by charts, that includes adequate material on the burning of fuels. This provides the boiler operator with a basic knowledge of the "know how" of combustion. A more advanced course of thirty lectures together with slide films has also been used with success.

Training methods were installed some years ago at a property operating two steam stations. With the same equipment and personnel operating under identical conditions that had prevailed for a number of years, a 16 per cent increase in efficiency was achieved at one station and 25 per cent at the other. This increase was computed as the average over a 4-year period compared with the preceding 7 years. The savings in fuel costs amounted to over \$9,000 during the 4-year period. At one of these plants an operator nearing 70 years of age learned to compute the plant efficiency and thoroughly enjoyed it. His capacity and interest were discovered through the medium of training, and were recognized by placing him in charge of the station, notwithstanding his advanced age.

When a group is of sufficient number, say six or more, the author favors the lecture-conference method of train-

ing supplemented by slide films where possible. Where such a method is impractical, there are other ways by which employees can extend their knowledge, with a little encouragement from management.

In the largest steam pumping plant in East St. Louis, engineers, the maintenance mechanic and some oilers have a loose-leaf manual in which are filed at intervals data containing information pertinent to some piece of plant equipment. It is hoped that ultimately this manual will be a complete operating guide for this particular station. Some of the plant staff have made contributions to the manual. Each man in this plant is fully aware that his work counts. He knows any suggestion he may have will be considered and appreciated, because the management is fully aware that many good suggestions come from the man who actually does the work. It is known that well-informed employees accept responsibility and discharge their duties with much more dispatch than those who are held in submission by misguided authority.

Office Employees

Now consider the office of the average water utility or department and the man or woman at the counter dealing with the customers. The contact employees may be called the "ambassadors of good-will," for that is precisely what they should and will be under a properly directed training program. Many phrases have been coined as guides to salesmen, such as "Know the product you're selling," and "Tell me in plain English what I want to know about it." It is the author's belief that the average customer coming to the water office with a complaint wants to be told in plain English what he wants to know about meters, pipelines, turbidity, hardness, milky water, and so forth. An unpleasant customer contact leaves a blemish upon public relations that cannot easily be erased. Why not prevent this from occurring by schooling contact employees in the fundamentals of the business, as well as the essentials of the art of "human relations"? The author has talked with a number of office employees, and it is his belief the majority will welcome any training program that will improve their knowledge of the business. If water works men want to enjoy to the fullest the good-will of their customers, they should try to create in each contact employee an ambassador of good-will. And the author has sufficient faith in people to believe the average employee will respond once it is made clear that management is interested enough to give him the opportunity to use his capacities and interests to mold good customer relations.

The Instructor

The success of any training program depends almost entirely upon the ability and enthusiasm of the instructor. No man can effectively instruct a group simply because he has been ordered to do so. He must be fully convinced that his work is of inestimable value, and maintain this attitude even though discouraging situations may arise. The strength and courage of one's convictions are prerequisite to success in any undertaking that has the aspect of an innovation. There is a certain reluctance or apathy on the part of some people to accept anything new.

A few guide posts for the instructor of a training course are:

1. Be well prepared.
2. Always remember that you will learn as you teach.

3. Keep your material on a high plane, but do not get high-hatted about it.

4. Protect your students by not embarrassing them if they do not know facts which may seem simple to you. There are some things at which you may not be too good.

5. Be sincere and honest. If a question is asked that you cannot answer, say so—and offer to find the answer before the next meeting.

Merit Rating

The final phase of a training program is a means to measure certain characteristics of people. This can be accomplished by merit ratings. If this technic is applied before training is started, and again at intervals, progress can be definitely measured. The accuracy of a merit rating system depends largely upon the ability of the rater. He must discard all notions of prejudice, partiality and personalities, and be governed entirely by unbiased facts.

The author's company has used with reasonable success an objective method of rating depending upon:

1. Quality of work
2. Volume or speed of work
3. Knowledge
4. Dependability
5. Character
6. Capacity for growth
7. Initiative
8. Relations with employees and public

Each factor was rated by applying one of five grades: exceptional, above average, average, below average, poor. Applying to this system a numerical weighting of $2\frac{1}{2}$ points for each grade, the exceptional grade is worth $12\frac{1}{2}$ points, and a person rating exceptional on all eight factors would therefore rate 100 points or per cent. In applying this method of rating to a typical water works operating group of 126 hourly employees from four departments—office, pumping, purification and distribution—it was found that 87, or about 70 per cent, were graded between 60 and 80 per cent, or from "average" to "above average." The rating was done by the four department heads, assisted by first-line supervisors, and final ratings reviewed by the manager.

The company considered that a great deal was achieved by the rating system. It started supervisors and department heads thinking in terms of people and showed why some employees do better than others. If used in connection with a training program, it will serve as a guide to the development and application of training work. Merit rating, like other forms of personnel work, is in its infancy; the methods may be changed as experience is gained. In the author's opinion, the system is here to remain as a vital and essential tool in personnel work, and it is indeed valuable as an aid to training.

Conclusion

Of all the Utopian ideas ever devised, none has appeared that is a substitute for productive effort. Nothing of value has been or ever will be produced without work. Attention, therefore, should be directed to the inescapable fact that the productive capacity of all should be increased. This can be accomplished in no better way than by the application of sound personnel policies that will include selection, placement, training and rating workers at both the supervisory and worker levels.

Developing Better Managers

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Presented on May 9, 1946, at the Annual Conference, St. Louis, Mo.

INDUSTRIAL management today is operating under more controls, more legislative inconsistencies, more social turmoil and reform, and more mumbo jumbo concerning economic panaceas than ever before in its history.

The problem of adjusting the basic and ancient proposition of competitive enterprise to today's fast-changing rules of business conduct has caused management no end of headaches. The necessity for curbing desires to attack its problems aggressively has created within industrial management a natural tendency toward defense and neutral positions until laws, directives, and even labor's position have been clarified. This certainly is an entirely new twist for American management which formerly thrived on alertness, originality and immediate, fast action.

Let us not forget also that workers today are of a much higher type—native-born rather than immigrant labor, considerably better educated, and constantly aspiring for a better job. Is it not natural then, since the worker level has improved, that managerial standards must improve correspondingly? Try placing an average gang foreman in charge of technical men in a control laboratory, and see the effect on morale, with all of its manifestations like griping, loafing, insubordination, labor turnover and so on. Workers do not have to be organized to register disapproval or a lack of confidence in superiors.

Another very important consideration is the "trend of economic thinking." As unsound as it may seem, the purpose of industry in the minds of many people is to furnish more and better employment for more people, so that the general standard of living can be raised. To others, this is putting the cart before the horse. Industry is founded upon venture capital. Venture capital is entitled to profit. In achieving its investment return, there are certain byproduct benefits that result, such as a source of livelihood for the individual, accelerated development of the community, and a general increase in living standard.

Regardless of viewpoint, the fact is that when a business fails to make money, it dies. Every member of the management team must thoroughly understand that the *cost* of a product or a service is the governing factor of any company. With all of the "isms" and new economies being preached today, executive management's only worthwhile contact for rebuttal in defense of the enterprise system is through the lowest foreman. Unless the foreman knows and is convinced that the advantages of private enterprise put all other systems in the shade, management has lost the most important single channel for communicating this to its

workers, for he is its on-the-spot salesman.

All this means that an entirely different managerial machine must be developed. Does this mean better management? It certainly does. Does this require closer harmony within the management structure of any one plant or company? Definitely yes. Does it require uniformity in understanding problems of operation and consistency in executing policy? Naturally. Does it require a better understanding of how to supervise workers? Of course it does.

The only way that this new management machine can be developed is through well-planned and properly executed programs for the training of foremen, supervisors, superintendents, department heads and assistant managers, all of whom comprise the management group.

Needs Felt by Supervisors

How do foremen feel about all this? Industry has taken the trouble to find out through nation-wide opinion surveys. In the author's own company a similar survey has been conducted among the foremen to obtain their reactions. It was learned that they recognized the necessity for improving management standards. They told inquirers, furthermore, that *cost* was an all-important factor in plant operation. Another feature that they called to management's attention was the confusion which arises from their attempt to understand all of the legislative and business controls under which they operate.

What did they want? Believe it or not, their requests all boil down to the three fundamental phases of their jobs:

1. Greater knowledge of the company and its operating policies.

2. A clearer picture of their responsibilities and instruction in discharging these responsibilities.

3. A better understanding of technics in handling manpower.

Monsanto foremen are no different from foremen in the automotive, wearing apparel, or utility industries. All foremen want the same thing and who else can give it to them but top management?

Company Orientation

Answering their first request for "greater knowledge of the company and its operating policies," is relatively simple. In the author's company, management (and this includes the foremen) developed a supervisory manual covering company history and organization, company practices, plant procedures and legislation affecting industry.

Some companies choose to handle this orientation on a lecture or a conference basis. In Monsanto plants a manual is used and, for the more important policies and procedures, lectures were given to obtain complete understanding. In addition, twice a year at each plant, members of executive management from central or divisional offices meet with the entire plant supervisory group to inform them of important developments within the company that affect their future. This has proved to be a valuable aid in developing "managerial unity."

Supervisory Responsibilities

The second request, for "a clearer picture of their responsibilities and instruction in discharging these responsibilities," requires special handling by the line organization. The first step must be one of clarification and interpretation of duties and responsibilities delegated downward within the line.

The next move is instruction through interviews, conferences or lectures covering recommended methods for discharging these responsibilities. Typical training subjects in this group are: cost control, quality, preventive maintenance, material handling, safety and so on. Training activities of this nature are considered plant problems at Monsanto and for the most part the central office has little to do with either the development of training material or the administration of the program beyond establishing a pattern. The central office can do no more because of the wide variation in plant operations.

Fundamentals of Supervision

The third request, for "a better understanding of technics in handling manpower," is unquestionably the most important part of the foreman's job. It certainly involves the most complicated and intangible phase of his work and is therefore the most difficult to apply as well as to teach. Developing the art of leadership in foremen to make them all replicas of Washington, Napoleon or Eisenhower is ridiculous. At best, all that can be accomplished is to temper the extremists: the introvert, the hot-head, the strong-willed, the militant and the weak. Training can only lay down rules for stability, impartiality, instruction, respect, self-analysis, sincerity and the building of confidence, morale and good-will, but the application of these rules is a personal matter for every foreman. This thought is very aptly expressed by John Boyle O'Reilly in his poem, *The Rainbow's Treasure:*

You may grind their souls in the selfsame mill,
You may bind them heart and brow
But the poet will follow the rainbow, still,
And his brother will follow the plow.

Unless the foreman is firmly grounded in the basic reasoning behind the rules that are supplied him during training, all the effort will be ineffective, and he will revert to chasing rainbows, or following the plow.

The problem, therefore, is to give every foreman a foundation upon which his leadership structure can be built. The foundation in general consists of these fundamentals of supervision:

1. The foreman deals with words. He must be able to transmit ideas to others. This is his most basic tool and the biggest difference between his job and that of the man below him.
2. He is the member of management delegated to represent his company to his workers.
3. His job consists of fusing materials, machines, methods, money and men to produce a desired result. His knowledge of how to handle each element efficiently is his stock in trade.
4. He was chosen for the job because his boss felt that he had the ability to process each element properly.
5. The most important and precious element with which he deals is MEN.
6. He is absolutely responsible for the actions and welfare of his men.
7. The attitude and progress of his men is an accurate barometer of his personal progress and status within the company.
8. He is the manager of a business within a business. Failing to operate his business at a profit is a reflection on his managerial ability.

When these fundamentals are firmly fixed in the mind of the foreman, then and only then is he ready for training in how to supervise people. And when this has been accomplished, and top management is convinced that the foundation has been completed, de-

velopment in the technics of handling people might then be initiated and encompass certain features that must be emphasized throughout the program, such as:

1. The importance of having an active, personal interest in people.
2. The need for self-confidence in winning respect of others.
3. Directness in reaching the minds of others.
4. Sincerity, honesty and impartiality when dealing with workers.
5. Personal enthusiasm and building of worker enthusiasm.
6. Delegation of responsibility.
7. Basing decisions on facts rather than opinions.
8. Instruction and follow-up technics.
9. Practical psychology.

Conclusion

The list might go on endlessly. But training can only produce an appreciation of the importance and magnitude of the problem of supervising workers, and provide a few rules that will assist in securing a more favorable response from workers. The use of foremen's conferences is recommended for conducting such a program. At these, the general problem is stated and discussed critically by the members, using case histories and examples. A great deal of work has been done in this field by the government in its training programs, and by professional organizations which provide training aids, such as sound slides, motion pictures, literature and the like.

The effectiveness of this phase of training is shown in the record of some companies which are known for their excellent relations with workers. This situation is not a matter of luck, but of long-range planning in management development and industrial relations. Supervisory training represents an investment in managerial unity, future leadership and worker loyalty, and can be evaluated only in the same terms. It is not a matter of training for the sake of educating members of management, but training based upon existing problems of supervisors.

If labor problems exist, supervisors should be schooled in the proper method of meeting these problems. If there are production or service problems to be met, supervisors should be trained accordingly. If it is merely wished to share company information with all levels of management (and this is tremendously important), supervisors must be told, trained to understand and execute company policy in the spirit in which it was intended.

Management must build and continue to build its foremen as an integral part of the entire managerial staff. They must be given all the responsibility they can bear with the authority to discharge these responsibilities properly. They must never be bypassed in dealing with employees, and, wherever it is humanly possible to do so, their decisions must be backed up in every respect.

The channels for exchange of information between foremen and top management must be kept wide open for a free flow and exchange of ideas. The foreman is only human; he wants the same treatment and degree of recognition that management would have him give his men. Remember also that the top management's ability to handle foremen is every bit as important to the success of the company as the foreman's ability to handle his men. Supervisory training is at the very foundation of a company's future growth and progress.

Employee Pension and Retirement Systems

By Dale L. Maffitt

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Presented on May 9, 1946, at the Annual Conference, St. Louis, Mo.

THE importance of retirement and pension systems in improving employer-employee relationships is no longer questioned. Within the last five years more employee retirement plans have been adopted than in the entire preceding history of business in the United States.

No doubt this trend was started by the passage of the federal Social Security Act in 1935. While the Social Security Act was designed primarily to meet a social need in providing against insecurity in old age and disability and in obviating the need for relief grants, particularly to persons of low income, its operation has led to the conclusion on the part of industry that it brings economic benefits as well. Consequently, business organizations have supplemented the social security benefits with pension and retirement systems which will provide more adequate benefits to retiring employees, and they have done this because it has proved to be a means of improving efficiency of operation.

Experience in American industry over a long period of years has indicated that a plan which aims at the systematic retirement of employees has definite economic advantages. Superannuated employees, whose ability to produce is limited, are separated from the active pay roll. The slowing of production by such less efficient employees is avoided, and younger employees are encouraged to put forth their best efforts because the opportunities for advancement are apparent. The general employee morale is improved through the realization that a definite income and some measure of security await the completion of a period of continuous service.

It has been demonstrated that retirement systems bring about increased efficiency in administration, and thereby effect a reduction in operating expenditures. Retirement provisions, therefore, cannot be said to create any additional burden for the employer. The expense of the system actually serves to offset previously concealed and unknown pay roll costs, very often resulting in substantial savings in overall costs.

Labor turnover and training costs are reduced and a better type of personnel is attracted to and retained by the employer. Community and general public relations are improved.

Formal Retirement Plans

Many employers may be fully aware of these economic benefits, and still may not realize the advantages of a formal retirement plan. In many instances the aged employee is kept on the pay roll, and either assigned to lighter tasks or released from all active duty. It is obvious that only a limited

number of employees can be assigned to lighter work, and by these assignments the path of advancement is blocked, and the employment of potentially valuable younger employees is prevented.

The retention of the super-annuated employee on the pay roll adds to the cost of production at a time when the employee is contributing little to the earnings of the business. Also, the aggregate group of aged employees tends to increase, both in number and as a percentage of active pay roll.

Another objection to such informal pension practices is that the employee has no assurance whatsoever that he will receive a retirement allowance, or, if received, that it will continue. While this aspect may seem entirely personal to the employee, it reacts against the employer in that he will not attract to his staff employees who could otherwise intelligently plan a career with him. Likewise, his present employees, who receive offers from competitors, can properly give definite consideration to benefits offered under a formal plan of the competitor.

If a business organization is to meet this problem of the super-annuated employee by means of a pension or retirement income, a formal pension plan should be installed. This is advisable because it sets aside profits for benefits, in years in which they are earned, to take care of those who have actually earned the profits through their labor. Any informal plan, left to the discretion and judgment of management, which takes care of old and faithful employees in their later years as the obligation develops, is a charge against future generations rather than the generation which is to receive the benefit.

A formal retirement plan should be carefully written, and all its provisions clearly understood by all employees. The plan should be financed in advance of the payment of benefits. It should be based on the primary desire of the employer to provide benefits on retirement from service, but may include supplemental benefits such as death benefits, disability or other separation benefits.

The establishment of a retirement system requires careful study. The amount of the retirement benefits and the type of other benefits provided must meet the needs of the individual business concerned.

The author's own theory of pensions is that at a predetermined age an employee should be able to retire, and the amount of income he receives, whether from social security, a privately established pension system or a combination of the two, coupled with the income he receives from money saved through insurance, bonds, real estate and so on, should enable him to live happily in his old age, in the manner to which he has been accustomed, and without financial worry.

Whatever type of plan is devised, and whatever benefits are provided, it is of first importance that the plan be actuarially sound, or it is not likely to survive, and the personnel benefits which the plan was intended to bring to management will not exist.

In return for its investment in a sound pension plan a company has a right to expect improved efficiency of operation, improved morale among employees, general reduction of turnover and the holding of key men, attraction of a better type of employee, and better public relations.

Group Insurance

Group insurance is another means of improving the employer-employee

relationship, which works to the advantage of both employer and employee. It has been estimated that only 10 per cent of absence from work is due to disability caused by accidents which are covered under workmen's compensation laws. Group accident and sickness insurance provides a weekly indemnity, over a limited period of time, in the event of disability resulting from any accident occurring away from work, or any disease for which the employee is under the care of a physician and for which workmen's compensation benefits are not payable. Group life insurance enables many employees, who might not be able to meet the requirements for an individual life insurance policy, to secure life insurance at a reasonable rate.

Costs of group insurance are ordinarily shared by both employer and employee, and the premiums are based on an average for the group. Definite advantages accrue to both employer and employee under a group insurance arrangement. Employees who become ill have a source of income during the time that they are not working. Without insurance of this type the employer must keep the employee on the pay roll while he is not working, and so add an unproductive labor cost to his operating expense. Or he must drop the employee from the pay roll at a time when the employee is ill and undergoing additional expense in the way of medical or hospital costs.

Group life insurance adds very little to the cost of group accident and sickness insurance as far as the employer is concerned, and is a distinct advantage to older employees with families, who might not qualify for, or be able to afford, ordinary life insurance.

Conclusion

The success of any business is dependent upon the character, loyalty and intelligence of its employees. The average employee takes a personal interest in doing his work well, and can be made to feel more responsibility if the employer takes the employee into a certain amount of confidence in the various problems and gives consideration to ideas and suggestions made by the employee to better the business.

It is a fact that the average employee gives selfish consideration to his own problems and to those of his immediate family, and when an employee understands that the employer is attempting to deal fairly and squarely in all transactions, and that his suggestions are appreciated, he will have confidence in the employer and will strive to do a better job, realizing the importance of the success of the business as it reflects back to his entire family.

The employee, too, can do either good or bad work in public relations, depending upon the training that he receives in such matters. The public's attitude towards an institution is definitely and surely reflected by the attitude and character of its employees.

Union Relations With Public Ownership

By Wendell R. LaDue

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Presented on May 9, 1946, at the Annual Conference, St. Louis, Mo.

THROUGHOUT the nation, the flurry of strikes against municipal governments by their employees is being observed with more than critical interest by both parties. Repercussions may follow, depending greatly upon the type of results and the degree of mutual understanding attained. In viewing the proceedings with studied impartiality, we seek the answers to several questions:

1. What are the legalities of union relations?

2. What are the rights of unionized governmental employees?

3. What is the thinking behind the "right to strike"?

4. What can a city commit itself to in a union contract?

The answers are so irrevocably interrelated that division is futile; hence, the following observations are made in a collective sense. All municipally owned water works are subject to the provisions of state codes and applicable municipal or home-rule laws. Although these regulatory requirements are dissimilar, the general principle involved is common throughout the country. Since the regulations are based on changing laws and current court interpretations, however, the problem is definitely in a state of flux; hence what is said today may be out-of-date tomorrow.

Federal Opinions

This public regulatory influence results in a peculiar employee-employer relationship, since it varies from the normal private labor pattern. Further, this relationship has been recognized both by governmental officials and labor, from the federal level to the municipal. Indeed, its peculiarity was recognized when, on Aug. 16, 1937, the late President Roosevelt, in a letter to the National Federation of Federal Employees, made the following statement:

> All government employees should realize that the process of collective bargaining, as usually understood, cannot be transplanted into the public service. It has its distinct and insurmountable limitations when applied to public personnel management. The very nature and purpose of government makes it impossible for administrative officials to represent fully or to bind the employer in mutual discussions with government employees' organizations. The employer is the whole people who speak by means of laws enacted by their representatives in Congress. Accordingly, administrative employees and officials alike are governed and guided and in many instances restricted by laws which establish policies, procedures or rules in personnel matters.

The Congress of the United States has recognized this peculiarity in rela-

tionship by exempting governmental units from the terms of the National Labor Relations Act, also known as the Wagner Act, and the Fair Labor Standards Act in almost identical language; through the definition of employer:

Employer includes any person acting directly or indirectly in the interest of an employer in relation to an employee but *shall not include the United States or any state or political sub-division of a state.*

Civil Service Procedure

Almost every state has laws establishing civil service, or the regulating of the employment of individuals in governmental service. For instance, a given state municipal code establishes civil service for most employees of the state, counties, cities and city school districts by providing that, insofar as is practicable, all persons shall be appointed as a result of competitive examination and no person shall be appointed, removed, transferred, laid off, suspended, reinstated, promoted or reduced as an officer or employee in the civil service of the state, the several counties, cities and school districts thereof, in any manner or by any means other than those prescribed in the civil service act, or by the rules of the state or a municipal civil service commission within their responsible jurisdiction.

Naturally, the portion of the charter of a given city pertaining to civil service parallels very closely the intent of the state law. Let us now, therefore, transfer our consideration to the local level.

A city's charter provides for the appointment of a personnel director who, under the direction of a commission, shall direct and supervise the administrative work of the personnel bureau; shall prepare and recommend rules and regulations for the administration of the civil service provisions of the charter, which become effective after approval by the commission; and shall act as the administrative head. A list of classified positions is formulated.

The wage or salary scale for each position is established by a wage and salary ordinance passed by the legislative body of the city and approved by the chief administrator. Hence, the effectiveness and even the existence of civil service employment is based upon the adherence to state and local laws.

The Right to Strike

Let us consider for the moment the "right to strike." The Thirteenth Amendment to the Constitution of the United States permits an individual to cease working if he becomes dissatisfied with his employment. The simultaneous stoppage of work by a number of individuals employed in like or related jobs is usually termed a strike. Edgar S. Furniss, Professor of Political Science of Yale University, collaborating with Lawrence R. Guild, Graduate Fellow, Yale University, defines *strike* as follows (1):

With regard to the strike the usual statement of the law is this: It is lawful to strike for any reason or for no reason. But laymen should not infer from this that no strike will be condemned as illegal; on the contrary, there exists a long record of court decisions which have held specific strikes unlawful. The confusion arises over the *meaning* of the term "strike." When the courts hold that all strikes are lawful, they define the term as "simple collective quitting of work," and their statement resolves itself into the truism that no man can be forced to labor against his will in this country. By the Thirteenth Amendment, involuntary ser-

vitude has been made unconstitutional. Accordingly, workmen cannot be forced to remain at their tasks against their will, even when they have entered into definite contracts to perform service for a stated length of time. If they leave their work while under contract to remain, the workmen will be held liable to civil action for the recovery of damages by the employer; but the fact that most workmen have no definite time contracts, together with the fact that those who have entered into such contracts rarely possess material wealth sufficient to justify suit for damages, virtually exempts all workmen from interference by the court when they decide to quit their jobs. This is all that is meant by the statement that the strike is always legal. As one writer states the matter, "What is really meant is that quitting work cannot be directly prevented."

But the definition of a strike as collective quitting of work is not broad enough to embrace all the implications of that weapon of trade-unionism. With rare exceptions, a strike is something more than a spontaneous and simultaneous surrender of their jobs by a group of workmen. It is preceded by a collective agreement among these workers to strike unless certain of their demands are granted. Before the strike occurs, the workers engage in concerted action through the union to bring pressure to bear upon the employer under threat of strike. The strike itself is a response to an order issued by the officials of a combination of workmen. While it is in operation, the strikers retain their coherence and continue to act as a unit with the intent to recover their jobs after the period of disturbance has passed. In all its phases, the essence of the strike consists in the combination of the workers for concerted and predetermined action.

Employees' groups, public and private, are banded together normally for the purpose of obtaining better wages or salaries and working conditions. In ordinary employee-employer relations this is accomplished as a result of a bargaining process between duly recognized and authorized representatives of labor and management. Usually this results in a mutually satisfactory working agreement; less frequently, in strikes to enforce the demands of the employees. The strikes are usually settled, with more or less loss to both parties concerned, as a result of further negotiation or arbitration. In governmental employment, however, the peculiar relationship referred to previously makes the normal functioning of employee-employer relationship impracticable, and, according to numerous court decisions, even impossible.

Strikes by Municipal Workers

A recent magazine article (2) lists strikes by municipal workers in Houston, Tex.; Scranton, Pa.; and Lexington, Ky., and threatened strikes in New York, N.Y., and Columbus, Ohio. Many of these strikes affected employees of the municipal water utilities. Strikes do, therefore, take place in governmental service. The analysis of the strikes indicates, however, that under agreement the city workers agreed to return to their jobs with civil service seniority and pension rights unimpaired, while the civil service commission agreed to begin an immediate study of city wage scales, comparing them with pay for comparable work in private industry in the affected area.

Court Decisions

Recent court decisions throw considerable light upon the usual conditions of a union contract which includes wages, working conditions, exclusive bargaining rights, the closed shop and check-off of dues.

On Feb. 1, 1945, the decision in the case of the *City of Cleveland* vs. *Di-*

vision 268, by the Court of Common Pleas of Cuyahoga County, Ohio, held that the Cleveland Transit Board is without power or authority (3):

1. To commit itself by agreement with a union to compulsory arbitration of disputes.

2. To recognize the union as an exclusive bargaining agent for Board employees.

3. To enter into any collective bargaining agreement, in the absence of any statutory or charter provisions.

4. To sign labor union agreements, even though the Board does operate the street transportation system in a proprietary capacity.

Compulsory arbitration of disputes was dismissed by the court, which held it vain and futile to refer the issues to arbitrators who, with the best intentions, but in ignorance of the civil service law, might make an award which it would be legally impossible for the Board to accept. On the other hand, the Board in all its dealings with employees is presumed to know the civil service laws and the charter provisions and to be governed by them.

As for exclusive bargaining rights for unions:

> The fact that Division 268 has as members a majority of the employees is immaterial. Such a law, or enabling act, passed by the state legislature, or city council would be unconstitutional. It would be tantamount to forcing all employees to become members of the favored union, and would be unlawful.

In the case of *Mugford* vs. *Mayor and City Council of Baltimore, Md.*, the purpose of a suit filed by taxpayers in the circuit court of Baltimore was:

1. To declare void the agreement of Apr. 8, 1944, between the Department of Public Works then acting and on behalf of the city of Baltimore and the municipal chauffeurs, helpers and garage employees, Local Union No. 825 affiliated with the AFL.

2. To enjoin and restrain the defendant from extending any preferential advantage or privilege to the union or its employees.

3. To enjoin and restrain the city from making any deductions from the wages or salaries of employees of the city of Baltimore for the payment of union dues for such employees to the union.

4. To secure such further relief as may be required.

The circuit court sustained the contention of the taxpapers in all but one respect. It invalidated the contract of Apr. 8, 1944, and permanently restrained the city from carrying it out and from making and carrying out any other agreement with the defendant's union, granting to such union and its members preferential advantage of any character over other employees of the city of Baltimore. But in the matter of check-off of dues, the court said that its decision shall not forbid the collection and remittance of such dues by the Central Payroll Bureau upon a purely voluntary basis, terminable by any employee at any time in any future contract between the city and the defendant's union. Upon this finding, the taxpayers appealed and the court of appeal stated:

> If a city employee voluntarily asks the Central Payroll Bureau to deduct from wages due him and remit the same to a person, partnership or corporation reserving to himself the right to discontinue such payments in the future, it would seem that the city could comply with the request.

In the case of *Hagerman* vs. *The City of Dayton, et al.*, the Common

Pleas Court of Montgomery County, Ohio, provided an interesting comparison with the Baltimore case. The court held that an ordinance of the city of Dayton requiring the City Director of Finance to deduct union dues from the earned wages or salaries of such city employees who had executed voluntarily written assignments is only legal and valid if the expense of making such deductions is paid from sources other than public funds. The court held that under applicable state law, the city could agree or disagree to such an assignment, as the language of the law is not mandatory. It further held that the services tendered by the employees of the city of Dayton and the supplies and equipment used for the deduction and transmission of union dues were clearly for the private convenience and benefit of such employees and union, and not for a public municipal purpose.

The importance of a Florida case involving the right of municipal employees to organize and obtain collective bargaining rights is indicated by the fact that it is now before the state Supreme Court in Tallahassee. The case, affecting the rights of state, county and city employees is before the court on appeal of the Miami Water Works Local No. 654 (AFL) of a circuit court decision last June. The decision dismissed the union's litigation to force City Manager A. B. Curry to recognize the group's right to bargain collectively. The court also turned down the union's appeal for a rehearing and the union appealed to the high court.

Other Opinion

In his arguments before the supreme court, the attorney for the union contended that no distinction is made in Florida's 1945 labor regulation act and the open shop amendment to the state constitution between public and private employers and that, therefore, the organization is granted recognition by state policy. Attorneys for the city, on the other hand, claimed that the labor regulation act referred only to private employers and that the constitutional amendment lacks a specific reference to public employers which would be necessary to include them within its scope.

Mayor Fletcher Bowron of the city of Los Angeles, requesting support of the City Council in his stand on the Los Angeles Police Department union, stated:

> A strike of public employees is a strike against their government, and this would be the first step towards the disintegration of an established form of government. Secondly, the city cannot legally, and will not engage in collective bargaining. . . . The fixing of salaries and other matters relating to employment must be accomplished not by entering into a contract, but by an ordinance and the adoption of a budget in the way and manner determined by the city charter. Moreover it must be understood that the ordinance, rules and regulations as fixed by boards or other rule-making authority in the departments must prevail over the constitution, by-laws or other regulations of the union or employees' organizations. All public employees hold, primarily, loyalty to the city and to the people.

The *New York Times,* reporting upon the strike of subway employees for exclusive bargaining rights, commented:

> The subway employees have no right to strike. They have accepted civil service status which gives them definite benefits but denies them the right to strike.

The Borough President of the Bronx stated:

Once a person becomes a City employee, he becomes a part of the government; to strike against the government is equivalent to desertion in the Army or Navy.

Corporation Counsel John J. Bennett, outlining the city's legal position, stated in part:

The Constitution of the State of New York, Article V, Section 6, provides that all appointments in the civil service of the state, and its political subdivisions, shall be made according to merit and fitness, to be determined wherever practicable by open competitive examination. The state legislature has enacted laws for carrying this mandate into effect and has fixed the rights of civil service employees. The duties and powers of the heads of governmental agencies are also prescribed by law. Nowhere in the law of this state is the head of any governmental agency given the right to name any single person or group as the sole and exclusive bargaining representative for all employees of any governmental agency. For the head of a governmental agency to do so would be in clear violation of law and of the rights of individual employees. The nature of civil service employment is a matter of statutory law. It is not a matter of contractual relationship and therefore not a matter for contractual negotiation. The head of a governmental agency can act, with respect to governmental employees, only in accordance with the provisions of law.

When the legislature of the state of New York enacted the "little Wagner act" granting rights of collective bargaining, it expressly excluded employees of the state, or any political subdivision or agency thereof. Because of the constitutional provision and state laws, it is clear that no one group of civil service employees can be granted sole and exclusive bargaining rights as against a governmental body.

To grant any one or a group of governmental employees sole and exclusive bargaining rights would violate the laws of the state of New York.

The *Times* further stated that the leaders would find that:

. . . public opinion will be strongly and irrevocably against them, and that it will still uphold the Coolidge dictum of a quarter of a century ago; that there is "no right to strike against the public safety by anybody, anywhere, any time." Some very good friends of labor have strongly held to the conviction that public servants—meaning civil service workers—do not have the right to strike. Among them may be mentioned Franklin D. Roosevelt and former Mayor La Guardia. For the civil service worker has his obligations as well as his benefits.

Legislation in Virginia

House Bill 114 passed at the recent session of the Virginia Legislature is the answer of that state to city or state employees who strike against their own Government. It reads:

A BILL

To provide for the termination of employment of employees of state and local governments and governmental agencies by reason of certain acts of omission or commission intended to obstruct or suspend activities or functions of state and local governments and to render such offending employees ineligible for re-employment in any such service during a certain period of time thereafter.

Be it enacted by the General Assembly of Virginia, as follows:

1. Section 1. Any employee of the Commonwealth of Virginia, or of any county, city, town or other political subdivision thereof, or of any agency of any one of them, who, in concert with two or more other such employees, for the purpose of obstructing, impeding or suspending any activity or operation of his employing agency or any other governmental agency, strikes or wilfully refuses to perform the duties of his employment, *shall, by such action, be deemed to have terminated his employment and shall there-*

after be ineligible for employment in any position or capacity during the next twelve months by the commonwealth, or any county, city, town, or other political subdivision of the state, or by any department or agency of any of them. In any such case it shall be the duty of the head of any department of the state government, or the mayor of any city or town, or the chairman of the board of supervisors of any county, or the head of any other such employing agency, in which such employee was employed, to forthwith notify such employee of the fact of the termination of his employment, and at the same time serve upon him in person or by registered mail a declaration of his ineligibility for re-employment as hereinabove provided. Such declaration shall state facts upon which the asserted ineligibility is based. . . .

Conclusion

Most of the above decisions are based upon legal phases of the problem. They are by no means unanimous and strikes are continuing to occur, laws of prohibition to the contrary. The human element will not be denied, as is evident from the following statement of Otto Seyferth, Chairman of the Labor Relations Committee of the U.S. Chamber of Commerce, in which he terms the Chamber's "basic philosophy" with respect to the labor-management relation:

> Industrial peace will occur only when there are sound labor-management relations. Sound labor-management relations involve the acceptance of mutuality of interest on the part of employer and employees in the success of an enterprise.

We must all remember that even in public, as well as private, business, we are still dealing with human beings, all affected by the same problems of "living together" in a world recently torn asunder by the failure of man to understand his fellow man.

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Union Relations With Private Ownership

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THERE is not actually much difference between labor relations in a privately owned or stock water company and a municipally controlled plant, since fundamentally the relationship is still one between so-called management and labor. It is very difficult to draw a distinctive line between management and labor in the water works field, as everyone employed in a water company is working hand in hand with everyone else on the common problem of operation.

Water companies as a general rule employ fewer people for the service rendered than any other industry. This results in a considerable degree of overlapping of what the unions choose to call job classifications. As it is only comparatively recently that there has appeared a definite trend toward the unionization of the water works industry, frequently the representatives of the union sitting down across the table to negotiate a contract are not familiar with the industry's problems and practices. It seems most important therefore, that in the early talks with union representatives a mutual understanding of the problem at hand be reached, so that, as the discussion proceeds, classification of employees, limitation of their duties and so on will not be confused or compared to those in other industries.

When negotiating a contract it is always well to remember that there are three parties concerned: the company, the employee and the union. What might be agreeable and equitable for one might not be acceptable to the other two, as each of the three has his own problems and perspectives. Each point of discussion should be carefully analyzed and weighed, not just in the light of present conditions and practices, but with an eye to the future. For example, depressions and booms do not affect water companies generally to the same extent that they do a manufacturing business, and similarly they do not affect the wages or the security of employment for the employees of a water company.

To be more specific, the author will endeavor to comment on various clauses which are paramount in the negotiation of any collective bargaining agreement, and will try to analyze some of the questions involved, both from management's and labor's points of view.

Arbitration

A collective bargaining agreement should be drafted in such a way that when an agreement has been reached between the parties, the relationships between those parties, as far as major problems are concerned, are fixed for the duration of that agreement. Invariably, however, there are alleged violations of the agreement, questions concerning its interpretation, and

grievances or complaints relating to working conditions not specifically covered by the agreement but which are legitimate subjects for discussion through the various levels of management during the life of the agreement.

The function of the grievance procedure is to provide a method for bringing those matters to the attention of management and for arriving at a satisfactory settlement.

Arbitration is often provided in collective bargaining agreements as the terminal point of the grievance procedure. Unions frequently attempt to encroach on the functions of management, however, by demanding arbitration without limitation. If the union succeeds in making arbitration the terminal point of the contract and if the powers of the arbitrator are not limited, management may find that it has transferred to a third party rights which it thought it had reserved to itself. It may even find that it has transferred to a third person the power to change the terms of a correctly bargained agreement. An agreement to arbitrate any issue that may arise is frequently termed "open end" or "unlimited" arbitration.

It is therefore desirable in those contracts in which arbitration is provided as the final step in the grievance procedure to limit the questions to be submitted to the decision of an arbitrator, to those subjects relating to the meaning and application of the terms of the agreement. Management cannot properly discharge its responsibility for the management of a business if every dispute between it and the union is subject to the binding decision of a third party whose powers are not circumscribed.

Unless management is well informed on all its managerial prerogatives and is in a position to maintain these prerogatives, it is generally considered unwise to agree to an arbitration clause, even one confined to the interpretation of the provisions of the agreement. Arbitration can result in leaving matters to a third party which were previously within the sole discretion of management and usually the third party does not have management's intimate knowledge of the background, personalities, conditions, costs or probable results of making specific decisions; nor is the arbitrator ultimately responsible for the results of his decision. Management must live with the results of its own decisions and can correct its own errors. The referee is absolved of responsibility after he makes his decision, and, whether it is workable or not, his decision is final.

Union Security

The first thing that any union negotiator will demand is one or more clauses guaranteeing protection to the union, and, although union protective clauses are not so important to unions as they were before the passage of the National Labor Relations Act, the historical objections to unions by a large segment of employers has made union protective clauses a traditional must in collective bargaining. Union officials usually consider that the contractual protection evidenced by union security clauses is needed to protect the union against disintegration, whether produced by employer discrimination or not. They further consider that their representatives in the plant should have special consideration and protection in order that there may be continuity of representation. In addition to these two local objectives, national and international leadership desire to see the

union movement as a whole grow in power and security.

"Union security" is only one of a number of union protective clauses that professional union negotiators will strive to obtain with all the skill at their command. The union protective clauses are those which serve to protect the status of the union, and may cover such matters as degree of union recognition, union security, check-off, avoidance of discrimination based on union status or membership, pay for union representatives for time lost from work in attending to union business, special seniority for union officials or other representatives, permissible union activity on company premises, posting of union notices, distribution of union literature and access to top management by union officials.

These provisions are usually considered to be of essential importance by the union negotiators, but the rank and file of employees are not likely to be equally enthusiastic about them except under exceptional circumstances. Of the various forms of union security, those most usually encountered are the closed shop, the union shop, maintenance of membership and the check-off.

Closed Shop

A closed shop is a contractual arrangement between the company and the union requiring all employees in the bargaining unit to be and to remain members of the union as a condition of employment; and requiring the employer to hire only people who are members of the union.

No attempt will be made here to review all the arguments for and against closed shop. The union argues:

1. That it needs the closed shop to achieve seniority.
2. That a closed shop is evidence that the employer accepts the union in good faith.
3. That all employees benefit by the union activities and therefore all of them should be required to support it.
4. That if a union is assured of membership and support through the closed shop it is free for constructive efforts in co-operating with management; otherwise the union must devote most of its effort to organizational work.

Management's arguments against both closed shop and union shop forms of security are, generally speaking, that:

1. It is repugnant to the American principle of freedom to require that any person join or refrain from joining any organization, whether it be a church, a lodge or a political party.
2. That the right to work wherever the worker elects to work should not be made dependent upon members in any organization.
3. Management is prevented from exercising its right to hire the best men for the job if it is limited to hiring union members only.
4. Relieved of normal organizational activity, the union leadership seeks to take over normal management functions.

In spite of the numerous objections to the closed shop, a number of examples of that form of union security exist. Sometimes the closed shop has been arrived at by collusion between an employer and a favorite union in order to discourage other unions or prevent them from getting a foothold. Other times the employer has agreed to a closed shop in order to avoid the disturbances incident to inter-union competition and jurisdictional disputes. A consideration of plants in which the

closed shop is in effect leads to the conclusion that the closed shop is no guaranty of labor peace or even stability of labor relations. It puts into the hands of the union a great power of compulsion and is subject to the objections applicable to any monopoly.

The primary justification for the closed shop is that it gives the union a maximum of security. But the union is merely the agent of the employees, and, under the closed shop, the security obtained by the union, which is the agent of the employees, is at the expense of compulsion exerted on the employees themselves, who are the principals. From the employee's standpoint, therefore, a closed shop means that he has traded away his freedom in union membership and job security in return for a doubtful strengthening of the position of his bargaining agent. To the employer, the closed shop means that union membership replaces merit as a criterion for employment. It is doubtful whether the closed shop represents a gain for either employer or employee.

Union Shop

The union shop differs from the closed shop in that the employer is at liberty to exercise initial freedom in hiring anyone he selects, rather than being required to hire union members; but the newly hired employee must join the union within a brief period of time after he accepts employment.

The union shop is subject to the same objections, except those concerning selection of new employees, as the closed shop.

While the union shop appears to give the employer full opportunity to select his candidates for employment, the practical effect is much the same as the closed shop. Those who refuse to join the union must be discharged. Furthermore, the union may refuse to accept certain people into its membership. If it so refuses, apparently the employer has no recourse except to discharge the employee involved. The distinction between the closed shop and the union shop, therefore, is more apparent than real.

Maintenance of Union Membership

Ten days after Pearl Harbor, the President called a conference of industrial and labor leaders to agree on a procedure for settlement of industrial disputes without interruption of production. The conferees agreed on (1) elimination of strikes or lock-outs, (2) peaceful settlement of all disputes and (3) creation of a War Labor Board to settle these disputes. Industrial representatives, however, insisted that the question of the closed shop, or any form of compulsory unionism, was not one that was amenable to arbitration.

The Executive Order creating the War Labor Board was silent on the question of compulsory unionism. Since the War Labor Board was given the authority to "finally determine the dispute," it necessarily had to determine what position it would take with respect to all questions in dispute. When demands for a closed shop and check-off came before the Board, it was faced with the necessity of (1) ordering compulsory unionism where it had not before existed, (2) refusing to order compulsory unionism under any circumstances, (3) freezing existing conditions covering compulsory unionism as they existed before each case was referred to the Board, (4) attempting a uniform union security formula or (5) considering each dispute on a case-by-case basis.

A majority of the WLB members, believing that labor should be rewarded for its no-strike pledge, but not prepared to compel workers to join unions not of their choosing, adopted the device previously used by the Defense Mediation Board of maintenance of membership, which is a compromise between the union shop and the open shop. Under a maintenance of membership provision, while employees are bound to maintain their membership in good standing during the life of the agreement, a 15-day escape clause permits them to resign from the union. The principal objection to the standard maintenance of membership clause is the fact that the determination of what is "good standing" is left to the union, and in the hands of irresponsible union leaders, may operate with gross unfairness to individual employees. "Good standing in the union" means compliance with all the rules and regulations of the union. Failure to remain in good standing may be used by contending factions against each other, entirely disregarding the question of resultant interference with production or rights of individual employees. It has happened on occasion that when a union is controlled by a small clique that disregards normal democratic procedure in administering the affairs of the union, it is a simple matter to put a member in bad standing by the mere passage of an arbitrary by-law and thus to compel his obedience to the will of the ruling group under threat of losing his job.

Check-Off

Check-off is a generic term meaning any arrangement under which an employee's union dues are automatically deducted from his pay checks by the employer and remitted to the union. A check-off may be voluntary or involuntary, revocable or irrevocable by the employee.

Voluntary Revocable Check-Off. This form of check-off authorizes the employer to deduct union dues only upon specific authorization of individual employees, the employees remaining free to revoke such authorization at any time.

Voluntary Irrevocable Check-Off. If the employee voluntarily signs an authorization to the company to deduct his dues and transmit them to the union for the life of the agreement, the check-off is voluntary but irrevocable.

Compulsory Check-Off. Compulsory check-off is automatically applied to all union members by the agreement.

Seniority

Seniority is a device used by unions to limit the exercise of managerial discretion in such fields as shift and job assignment, promotions, wage increases and transfer.

There is justification for giving weight to seniority as an important factor when laying-off and rehiring; there is justification also for considering length of service as one of several important factors in shift and job assignments and even in transfers and promotions, but if seniority is considered the *determining factor* in these fields, managerial discretion has abdicated from important fields that require sound judgment and has been succeeded by mechanical succession, which entirely neglects merit and ability. Employees themselves are likely to resent failure to promote the most able candidates when a position is open. There can be no doubt that the substitution of time-serving rather than ability, as a criterion in making

promotions, especially to managerial positions, must inevitably result in the crippling of management's effectiveness and efficiency.

An important element of the seniority provision is the determination whether seniority shall be by groups or whether it is to be plant-wide. Much depends upon the size of the plant, nature of operation, number and variety of products, differences between various departments and so on. For example, if the plant has departments that work on different and unrelated products, lay-offs in one department may differ in time and degree from lay-offs in other departments. Plant-wide seniority in such plants would entail not only wholesale and continuous transfers from one department to another, but also transfers of work assignments within departments. A considerable degree of confusion is bound to result, especially when employees are transferred from their own departments to others in which the work is of an entirely different nature.

Unions frequently prefer straight, plant-wide seniority: "seniority shall prevail on a plant-wide basis and shall be based on cumulative service." Employers usually prefer departmental seniority, which is much simpler to administer.

The word "seniority" has a strong emotional appeal to the average employee. On the surface it appeals to the sense of justice and fair play: "first come, first served." More than that, seniority may be considered as a tacit recognition of the concept of a right to a particular job. Employees are more likely to recognize length of service rather than merit or productive efficiency as a basis for judging past performance and for determining job preference, transfers, promotions, lay-offs, rehirings and so on.

For that reason, it is desirable to include in a collective bargaining agreement a provision that, whenever it becomes necessary either to reduce or increase the number of employees of the company, they shall be laid off or rehired according to seniority, those having the most seniority being laid off last and rehired first, *if such employees are relatively equal with respect to the factors of skill and ability to perform the work required in a satisfactory manner.* Furthermore, it is desirable to provide that employees shall be advanced in their respective departments to better paying positions covered by the provisions of the agreement, on the basis of seniority where such employees *are relatively equal with respect to the factors of skill and ability to perform the work required in a satisfactory manner.*

Furthermore, every seniority provision should contain a comprehensive list of conditions under which seniority is lost, such as by discharge, quitting, excessive absenteeism, being laid off for six months or more, failing to return to work when notified or being unavailable for work.

With the end of the present war, the principle of seniority is receiving increasing emphasis. From the union's viewpoint, seniority means elimination of management discretion, and possible discrimination or favoritism, from another and broad field of management functions. Unions can be depended upon to insist more and more urgently on seniority, not only in lay-offs and rehirings, but also in transfers, promotions and shift and job preferences.

From management's standpoint, the principle of seniority as applied to lay-offs and rehiring has proved sound,

provided that (1) occupational qualities and abilities are observed, (2) provision is made for exceptional employees and (3) seniority is not extended to matters other than lay-off and rehiring.

From the viewpoint of the employee, seniority is a double-edged weapon. It operates in his favor in providing some measure of job security, but if extended to job or shift preference or promotion, seniority favors the time server rather than the competent worker. Progress is stunted when incentives for skill and ability are replaced by length of service as the sole criterion. If employees were convinced that management assigns work and makes promotions on the basis of merit, it is doubtful that they would approve the extension of seniority preference to these fields.

Guaranteed Annual Wage

This term as used by unions is inaccurate and misleading. The only word which is accurate is the word "guaranteed." The proposal is not for an annual wage but for a minimum weekly payment for each and every week for the duration of a contract between the company and the union involved whether or not any work is performed. It is really a plan for compulsory unemployment compensation to be superimposed on the existing social security system, to create a preferred class of labor and to be financed by the imposition of a special tax on employers.

It would seem that such a demand has no place in the utility industry where there is practically no employment fluctuation whatsoever.

In the report of one of the broadest programs of social security ever proposed, submitted to the British Parliament by Sir William Beveridge, there is no recommendation of guaranteed employment or wages. Moreover, Beveridge makes it plain that no law or agreement or guaranteed employment will dispose of unemployment. He says (1):

> In industries subject to seasonal influences, irregularities of work are inevitable; in an economic system subject to change in progress, fluctuations in the fortunes of individual employers or of particular industries are inevitable; the possibility of controlling completely the major alternations of good trade and bad trade which are described under the term of the trade cycle has not been established.

The principal reasons advanced against granting of a guaranteed annual or weekly wage are that:

1. The problem of unemployment cannot be solved by requiring employers to guarantee work or wages. Unemployment itself is not the cause of unemployment. Unemployment seems rather to be the result of numerous other conditions and developments.

2. There is little precedent in American industry for a guarantee of wages on an annual or weekly basis.

3. The guaranteed wage would not create economic stability. It is the inability, not the ability, of wages, prices and production to conform to changing consumer demands that contributes to general unemployment.

4. The guaranteed wage demand would be grossly preferential to organized labor.

5. A guaranteed wage would tend to curtail employment and depress wage rates. Under a compulsory guarantee, employers would be competitively compelled to hire no more employees than those needed to handle the minimum forseeable demand for their products within the guarantee period. An employer who overhired would be

weakened by the consequent depletion of his resources and so would be less capable of competing. The attempt to guarantee full employment could thus evolve into a guarantee of reduced employment. It would seem to be but a matter of ordinary observation and simple reasoning to conclude that if people could not be hired for less than a specified period, they would not be hired at all unless work for the full period was in sight. One will not hire a gardener to do a year's work in his garden if only a half year's work must be done, unless the gardener will hire out at half pay. In a statement to the National War Labor Board on the dispute between the Carnegie-Illinois Steel Corporation and the United Steelworkers of America, Mr. Bradford B. Smith said:

> The demand (for guaranteed wage) essentially proposed to introduce an astounding new principle into American life, namely, that the authority of government shall be invoked to deprive employers of their property for the benefit of persons from whom they may receive no compensating service at all.

Fringe Issues

It is becoming customary for unions to demand the inclusion in collective bargaining agreements of various benefits which have historically been outside of the field of collective bargaining. A few of those demands are outlined below.

Pay for Holidays Not Worked

Ordinarily, hourly rated production and maintenance employees are not paid for holidays not worked. Union demands for this form of wage adjustment, however, have become increasingly frequent, and recently it has been the custom to grant from one to six holidays with pay even though no work is performed on those days. It must be borne in mind that pay for holidays not worked constitutes an item of expense for which the employer receives no return. An adequate vacation provision should be enough to counter demands for pay for holidays not worked.

Call-In Pay

Recognizing that an employee has been inconvenienced if he has been either called to work or permitted to come to work on his regular schedule and there is no work available for him, it is not uncommon to pay the employee two to four hours' pay. This may be regarded as payment for the inconvenience to which the employee has been put and conversely is a penalty on management for failing to notify the employee not to come to work. It is not unreasonable to provide some such clause in the agreement to protect the employee from being called or coming to work and finding that there is no work for him to do.

Health, Safety, Insurance and Pensions

There are many clauses pertaining to health, safety and employee benefits of various kinds.

The employer must satisfy himself that a prospective employee meets his standards before he is to be employed. Accordingly, it is exclusively a management function to set health standards for prospective employees and to administer such health standards.

Since the general question of safety in the plant is clearly a company responsibility, no mention of it need be made in the collective bargaining agreement. It may be desirable to include a clause in the agreement, however, to the effect that the company shall con-

tinue to make the same reasonable provisions for the safety and health of its employees which it has made in the past.

With respect to insurance, aid societies, pension schemes and so on, it is recommended that these matters be excluded from the collective bargaining agreement. Such matters have historically been outside the field of collective bargaining. Historically, these have been provided by employers at their discretion and have been regarded as an exercise of the employer's social responsibility toward his employees, the type and extent of plan depending on the employer's ability and concern.

Shift Premiums

Bureau of Labor Statistics Bulletin No. 686 states: "In continuous process industries, such as blast furnaces, pottery and glass, where shift rotation is usual, wage differentials between the various shifts or for Sunday work are very infrequent." In its origin the principal purpose of the shift premium was a stimulus to night work. Prior to the rapid industrial expansion for the production of war materials, it was customary in many fabricating shops and other establishments engaged in asembling or machining operations to operate normally on one shift during daylight hours only. It is significant that such operations could cease at practically any hour of the day or week without damage to facilities or materials in process, inasmuch as the various machine tools and equipment could be stopped merely by pushing a button, and without further ado the employees could leave the premises until the next scheduled period of work.

It is apparent, therefore, that premium payments for night work were based primarily on the conditions peculiar to the operations of the establishments and no doubt were influenced further by the fact that in peak periods a scarcity of qualified employees made necessary certain premium payments to secure their services under any but the most desirable conditions. The fundamental basis for establishment of shift differentials has no connection with the distinctly different processes and requirements for the continuous operation of water companies and, therefore, union demands for shift premiums in such operations should be denied.

The Right to Strike

The right to strike by any group of employees, whether organized or unorganized, and whether employed in an industry essential to the health and welfare of the public or not, has never been denied. On Mar. 11, 1946, however, a Utility Strike Bill was adopted by the New Jersey Legislature. The measure declares that utility services are essential to the public welfare and provides for: (1) a 60-day notice of contract changes during which compromise must be attempted, (2) intervention by the state Mediation Board and (3) operation of utility plants by the state when threatened with suspension of service because of labor disputes. No other states at this time, to the author's knowledge, have enacted such a bill.

References

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2. Union Agreement Provisions, Bulletin No. 686. U. S. Dept. of Labor, Bureau of Labor Statistics, Wash., D. C. P. 99 (1942).

A Scheduled Maintenance Program for Water Works

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SCHEDULED maintenance may also be termed "preventive maintenance," for scheduling maintenance work is of little value unless a preventive type of work is done. Conversely, preventive maintenance can not be effective unless it is done according to schedule.

Preventive maintenance in a water works plant is much the same as in a doctor's office. The "patient" is first given a thorough exterior physical examination. Then the "doctor" uses proper instruments to measure revolutions per minute, pressures, vibrations, and misalignments. He will make fuel tests, take indicator cards of valve action, and may check internal corrosion and bearing wear with x-ray. All of these technics are used in the water plant. The engineer, however, has one great advantage over the doctor—he can more easily take his patients apart to inspect and correct internal wear.

Both find it advisable to call in outside specialists. Few doctors are equipped to provide all the services a patient might need. Specialists are asked to investigate circumstances in their particular fields. The patient may be sent to a laboratory or hospital to have special tests made. Similarly, the services of outside engineers or mechanics may be called for when examination of certain equipment cannot be made efficiently by the regular personnel. Large electric motors may require inspections by electrical engineers with specialized and costly instruments. Tank erection companies may be particularly qualified to diagnose the severity of the internal corrosion in a water storage tank. The electric utility may have the only engineers qualified to determine the condition of power transformers.

The primary purpose of preventive maintenance, therefore, is to keep service equipment and facilities continuously in proper operating condition and repair. Preventive maintenance should prevent equipment outages and maintain original efficiencies and serviceability over the useful life of the equipment.

Basic Preventive Maintenance

Preventive maintenance, to accomplish this general purpose, should be made up of the following basic care operations, performed at definite intervals and following a systematic plan of inspection, diagnosis and repair:

1. Any unusual sound or change in appearance should be investigated. For example, a knock in a gasoline motor, chattering in a centrifugal pump, thumping in an air compressor or a

squeak in a chemical feeder are often early signals of mechanical failure. Similarly, a wobbly V-belt sheave, a chain drive riding high on the sprocket teeth or gears not fully meshing are also indications of incipient mechanical failure requiring immediate attention. Obviously, an operator should report any such changes that he notices. During the periodic check-ups made on each piece of equipment, however, the more critical eye and ear of a competent mechanic will often detect operating irregularities which an operator will miss.

2. Equipment must be kept clean. Moisture, dirt, dust, cobwebs, bugs, spilled oil, and so on, are definitely enemies of mechanical and electrical equipment. Birds' nests in outdoor switching gear, bugs in lubricating oil and dust in motors may cause failures that could be prevented by keeping equipment clean.

A vacuum type cleaner and a compressed air line for blowing out equipment are almost "musts" for keeping equipment clean. Then, too, if equipment is to be kept clean, the surroundings must also be kept clean. The mopping of floors, removal of debris from buildings, cleaning of cobwebs from ceilings, elimination of oil drip and general "good housekeeping" are important aids to keeping equipment clean in any preventive maintenance program.

3. Equipment must be protected against external conditions which may cause general deterioration or damage. Open motors should be protected from dust; machinery requiring the dissipation of generated heat should be ventilated; and equipment which would be harmed by water should not be located near potentially leaking pipes, tanks or fixtures. The operator or the mechanic concerned with preventive maintenance must be able to recognize conditions external to the equipment that might cause its deterioration, such as improperly placed lockers cutting off ventilation, the incorrect use of a water hose near motors, the use of an air hammer or paint spray near open bearings or motors, or the like.

4. Equipment must be kept in a state of "good order." For example, metal subject to corrosion should be painted or kept under a protective covering, nuts and bolts should be tight, leaning power poles should be straightened, sagging guy wires should be put in tension and leaking roofs should be repaired.

5. Conditions which cause heat in excess of that for which the equipment was designed should be corrected. Excessive heat may indicate incipient mechanical failures from any number of causes, such as improper lubrication, improper fit, overload, or the like.

Often "excessive heat" must be defined from manufacturers' recommendations or other experience records. Thermometers or surface pyrometers frequently must be used to measure temperatures. "Touch-of-the-hand" methods for determining excessive heat are usually unreliable. Two different operators may not have the same touch sensitivity, or two different bearings may have decidedly different heat tolerances.

6. Vibration must be watched and corrected if excessive. Vibration or vibration tolerances must sometimes be defined and a vibration meter used to determine the magnitude. A 10-mil vibration for some equipment is excessive and for another kind of equipment is well within safe limits (1). Preventive maintenance requires an understanding of what vibration is.

Vibration may be caused by misalignment, out-of-balance equipment, loose nuts and bolts, structural breaks, and so on. When vibration does occur, all contributing causes must be carefully checked. Maintenance of both static and dynamic balance (2) of such rotating parts as pump impellers and motor rotors is especially important in the prevention of vibration. Some phases of preventive maintenance require routine dynamic balance checks in addition to static balance checks.

7. Periodic tests for proper operation should be made. Mechanical trouble is often discovered by a testing procedure which shows the equipment to be incapable of full-capacity performance, or to be operating inefficiently or under conditions for which it was not designed. Such testing procedures may be relatively simple but nevertheless important in preventing operational failures. A chlorinator or a gasoline engine that will operate satisfactorily at one-fourth-capacity rating may develop trouble when given a full-capacity operating test. A pump efficiency test, which may merely require the reading of existing meters and the calculation of efficiency, might indicate worn parts.

Other tests, which might require more time and trouble but which also are properly a part of any preventive maintenance program, are a drop test on a filter or a basin to determine proper meter registration or a lime slaker heat balance test.

8. Equipment must be properly lubricated. Proper lubrication means the proper lubricant properly applied. Over-lubrication is as serious as under-lubrication. An effective preventive maintenance program should include a carefully worked-out lubrication plan. As an example, different pressure grease fittings could be used for each different lubricating grease to prevent misapplication. Or a color and symbol scheme might be used to mark both the points of lubrication and the container or grease guns storing the lubricant. The misapplication of lubricants is a common occurrence and must be prevented.

9. Wear must be watched for and corrected before it becomes excessive. Such inspections often require the complete disassembling and reassembling of the equipment. Centrifugal pumps, for example, may be given an annual overhaul in which, when necessary, bearing and ring clearances are restored, sleeves rebuilt, casings painted, impellers balanced and so on. This should result in continued pumping service without breakdowns or loss in efficiency. Chemical feeders, motors, rate-of-flow controllers, and the like, should be similarly overhauled on a periodic basis so that worn parts will be discovered and breakdowns prevented.

Value of Preventive Maintenance

It may properly be asked whether scheduled maintenance is worth while. Just what does scheduled maintenance accomplish?

Unless there is a profligate amount of standby equipment installed, a plant cannot let its major pieces of machinery run until they fail and then repair them. Equipment has the uncanny habit of breaking down just when it is needed most, or when it is most difficult to repair. Any program which will generally enable equipment to operate efficiently for a fairly definite future period is worth a great deal. Continuity of supply is one of the primary requisites of a water works system. Any steps which will increase the re-

liability of water works equipment, at reasonable cost, are justifiable.

A scheduled maintenance program will enable the maintenance mechanics to produce the maximum amount of results. If machinery is operated until it fails, the repairs must be made at the time of failure. If several pieces of equipment fail, or are ready to fail, at the same time, the maintenance force will be overworked. Then periods will occur when little work appears to be required, and mechanics will have little to do. Maintenance will be on a "feast or famine" basis, unless the work is scheduled.

It cannot be said that there is little need for scheduled maintenance in a small plant simply because everything is under the operator's eye. Actually there is probably more need for conscientiously setting up a scheduled maintenance program in a small plant than there is in a large one.

Maintenance in a large plant will usually gravitate naturally toward the preventive type. The management and supervisors direct a group of specialized workmen who follow fairly systematic patterns. Supervisors organize the efforts of the employees so that emergencies are minimized and the work load is as uniform as possible. Preventive maintenance is thus scheduled in varying degrees.

In a small plant there is usually a minimum of supervision. The operators lay out their own work, and comparatively few will lay out schedules for themselves. Under pressure of their varied duties, their tendency is to take care of the obviously pressing chores, letting tomorrow look out for itself. As a result more emergencies occur in small plants than in large ones. And when failures occur, they are generally more difficult to repair in a small plant; the big city supply of repair materials is miles away, and the technical skill required may be lacking.

It is difficult to make a comparison of maintenance costs between plants which do and do not practice preventive maintenance work, for plants similar enough to allow definite comparisons of maintenance costs are hard to find. It is also difficult to compare costs before and after a preventive maintenance program has been initiated. Maintenance of new equipment costs little, and equipment can be allowed to operate for some time without attention to wear. Then, when a preventive maintenance program is started, the maintenance costs may be higher than the previous costs, since the maintenance will then include both current and deferred maintenance. The simple fact that when preventive maintenance is once undertaken it is usually continued points to the value of such a program.

Establishment of a Scheduled Maintenance Program

Although the actual institution of a scheduled maintenance program calls for setting up certain record and report forms, and routines for handling them, the practice of scheduled maintenance involves several additional factors.

The first requirement is the definite assignment of responsibility for organization and development of a proper maintenance organization. In the process of assigning such responsibility, care must be observed to keep from over-burdening key men with routine duties that consume all or most of their time. Instead, the routine work should be delegated to men best adapted to it.

The importance of having preventive maintenance responsibility clearly de-

fined should not be overlooked, for it circumvents the tendency to "let George do it." Most men respond to responsibilities definitely assigned and take pride in excelling at them.

The second requirement is for a system that is flexible enough to allow for the unusual jobs that are bound to occur. Preventive maintenance is certain to fail unless man-hours in excess of those required for scheduled maintenance are provided for the repair of breaks and the construction of operating aids and improvements. The amount of such excess maintenance time will vary with the various type water plants. It may be approximated as 20 to 40 per cent.

The third requirement is a clear understanding by all plant operators and employees of what preventive maintenance means. They must get into the habit of thinking and acting along the lines of preventive work. They must be trained to look for minor indications of equipment deterioration and loss of efficiency. They must understand that good housekeeping is not valuable for the sake of good appearances alone; good housekeeping keeps equipment in good order. While some selling of employees on the benefits to be obtained by scheduling preventive maintenance will be required, the employees will usually accept willingly the attempt to channel their efforts into systematic lines of work. They will cooperate in any program which will insure the good condition and reliability of the equipment with which they work.

Next, management will have to provide the tools, and outside technical services when necessary, to enable the employees to carry out a program of preventive maintenance. Too many plants do not possess even such simple tools as feeler gages, pressure gages, micrometers, thermometers, adequate wrench sets, good paint brushes, and so on. In large plants, presses, electric and gas welding and cutting outfits, metallizing equipment, sandblast equipment, tong ammeters, recording ammeters, voltmeters, thermometers, pressure gages, "meggers," indicators, tachometers, and similar testing and maintenance tools may be needed. Where plant personnel does not include men with necessary skills, or where costly items of equipment are not used often enough to warrant the investment necessary to obtain them, arrangements should be made for hiring necessary specialists and renting necessary equipment.

An adequate supply of spare parts is equally as important as having the proper tools. The number and kind of spare parts which should be in stores will, obviously, be determined by the service conditions, the importance of the equipment to utility service and the ease with which repairs can be made.

A spare parts inventory and stores record is usually implied. In making such an inventory, the spare parts required for each piece of equipment must be considered, giving special consideration to small parts such as shear pins, nuts, bolts, diaphragms, valves, fractional horsepower motors, gear reducers, solenoids, contacts, brushes, fuses, gaskets, packing, and so on.

Equipment Maintenance

The initial step in establishing a preventive maintenance program is a study of the preventive maintenance required by each unit of equipment. This is only determinable after a thorough analysis of service conditions, operating experience and manufacturers' recommendations. Each machine or facility must be considered individually, for similar

TABLE 1

Preventive Maintenance for No. 1 Chemical Feeder

Frequency	*Work To Be Done*	*Basic Care Principle*
Daily	1. Empty feed belt and clean of all material which influences the "tare weight."	Keep clean.
	2. Clean dust from feeder compartment and mechanism, using vacuum cleaner.	Keep clean.
	3. Wipe knife edges with a soft cloth.	Keep clean.
	4. Balance scale without load and record the change (if any) in tare weight counterpoise setting.	Check for proper operation.
	5. Check for oil leaks.	Replace worn parts.
	6. Carefully observe the operation of feeder mechanism and agitators by noting unusual sound or operating appearance.	Investigate unusual sound or operating appearance.
Weekly	1. Tighten loose nuts and bolts where necessary.	Maintain state of good order.
	2. Check belt tension.	Maintain state of good order.
	3. Examine for loose or defective wiring where exposed.	Maintain state of good order.
	4. Check agitator and motor bearings for heating.	Prevent heating.
Monthly	1. Check the actual delivery of the feeder against the indicated delivery by the counter.	Check for proper operation.
	2. Clean rate of feed recorder. Clean pens by forcing water through points.	Keep clean.
	3. Protect metal against corrosion by touch-up painting where necessary.	Maintain state of good order.
	4. Blow out dust from motors and starters.	Keep clean.
	5. In case contacts in electrical switches are pitted or not making firm contacts, brighten with fine emery cloth. If necessary, adjust so that contacts are firm.	Maintain state of good order.
Annually	1. Overhaul feeder. Remove feeder belt assembly, motor, belts, etc. and then clean and paint entire structure.	Maintain state of good order.
	2. Inspect for and replace or repair worn parts.	Replace worn parts.
	3. Drain oil, flush and refill speed changer and vibrator. Lubricate and oil where necessary.	Lubricate.
	4. Drain, clean and inspect solution tank. Paint solution tank exterior and underneath side of cover.	Maintain state of good order and replace worn parts.
	5. After reassembling, carefully check agitator bearings alignment, sheave alignments and test for proper operation.	Eliminate vibration.

pieces of equipment may have different service and care requirements. The inspections, servicing and care comprising preventive maintenance should be itemized as briefly as possible, along with the frequency period (that is, monthly, quarterly, annually or the like) for each item. The use of the previously mentioned basic care operations in a check list will help avoid inadvertent oversight of necessary work. Such itemizing and frequency assignment of operations required by every item of equipment are the bases upon which a preventive maintenance program can be built.

Table 1, as an example, is a listing of preventive maintenance operations on a chemical feeder operating under very definite service conditions. The

Property No.	B-105.03 No. 5	CARD NO.	B-105.03 No. 5 B-A
DESCRIPTION	Straight Line Collector Mechanism No. 5 Pre-Sed Basin	FREQUENCY	Annually
		TIME	October
WORK BY	Basin Operator		
ACCOUNT NO.	L- 743-31 M- 743-31		

WORK TO BE DONE:–

1. Drain No. 5 Pre-Sed Basin. Clean basin and mechanism thoroughly, using pressure water hoses.
2. Inspect all sprockets and chain for wear and cracks. Replace where necessary. Turn sprockets and chain around, where possible, to prolong useful life. If chains are riding the teeth of sprocket and jumping, replace both sprocket and chain.
3. Adjust chain tension and check sprocket alignment. On flight chains, remove links where necessary to restore proper tension, the same number of links must be removed from each chain in a pair.
4. Inspect drag flights for wear. When necessary, request welder to build up wearing edge with hard surfacing welding rod.
5. Tighten all nuts and bolts. Note especially nuts and bolts fastening drag flights to flight chain.
6. Remove bearing tops on at least two bearings for bearing and shaft wear inspection. If wear is indicated, also remove tops of remaining bearings for inspection. Request maintenance department to repour worn bearings.
7. Inspect basin drive shafting. Check alignment, measure bearing clearance, report or repair faulty clutch operation.
8. Lubricate bearings out of water with 3 H grease. Do not lubricate underwater bearings or chain.

ST. L. C. W. CO. MAINT. PROGRAM FORM NO. 1

FIG. 1. Face of Maintenance Card for All Files

DATE	REPORT	INITIALS	DATE	REPORT	INITIALS
10-20-40	J.R. 605	S.D.			
10-5-41	J.R. 3044	S.D.			
10-25-42	J.R. 6180	S.D.			
10-19-43	J.R. A1489	S.D.			
10-18-44	J.R. A2355	S.D.			
10-19-45	J.R. B1585	S.D.			

FIG. 2. Reverse of Assignment Card

"work to be done" often is a composite of several of the basic care operations previously given. As usual, keeping equipment clean, painted and in a state of good order are basic care operations given great emphasis.

Requirements of a Preventive Maintenance Program

Following this study of preventive maintenance required by equipment, a program of preventive maintenance can be formulated. The program, comprising records and a system for handling those records, must be so constructed that (1) preventive maintenance assignments are made regularly and routinely without relying upon any individual's memory or private notes; (2) those persons responsible for and closely interested in water plant operation may readily know what inspections and other preventive maintenance operations have been scheduled, when and how often these operations are to be done, who is to perform the work, and when the operations were last completed; and (3) changes in scheduled preventive maintenance for any unit can easily be made when necessary.

Program at St. Louis County Water Co.

The St. Louis County Water Company uses a preventive maintenance program which meets the basic objectives given in the preceding paragraphs and in which the basic care operations previously listed are broadly applied. This program is simple but highly effective, and has earned the enthusiasm of mechanics, operators and supervisors alike. The remainder of this paper is a brief description of the plan, including a few minor modifications which are believed to be improvements.

The company's program of scheduled maintenance was started about fourteen years ago by Vance C. Lischer, formerly Engineer in Charge of Production. Starting with simple reminder cards covering the more important pieces of equipment, the system has gradually been enlarged until it covers practically all of the plant equipment and structures. Numerous suggestions regarding improvement of the program have come up from the maintenance men and operators, all of whom realize the benefits that are obtained.

Machinery for making the program flexible and subject to revision was found to be just as important as setting up the program itself. Intervals between inspections were often found to be either too short or too long. Lack of manpower, particularly during the war, required necessary revisions. Sometimes work was originally assigned to men with either less or more than the skill necessary for effective and economical performance. Changes were suggested by workmen in some instances; in others the revisions were initiated by the Maintenance Planning Committee, a board of review made up of certain of the supervisors charged with plant operation and maintenance.

Maintenance Cards and Files

Four basic card forms and four separate files are used in the operation of the program. These are:

Cards

1. Assignment Card (1 copy)
2. Office Copy Card (1 copy)
3. Property Card (1 copy)
4. Calendar Card (1 or more copies)

Files

1. Work Reminder File
2. Current Work File
3. Property Maintenance Directory
4. Calendar Maintenance Directory

ASSIGNED			COMPLETED	ASSIGNED			COMPLETED
DATE	TO	J. R. NO.	DATE	DATE	TO	J. R. NO.	DATE
10-1-40	Daffron	605	10-20-40				
10-1-41	"	3044	10-5-41				
10-1-42	"	6180	10-25-42				
10-3-43	"	A1489	10-19-43				
10-3-44	"	A2355	10-18-44				
10-1-45	"	B1585	10-19-45				

FIG. 3. Reverse of Office Copy Card

The cards are 5 in. by 8 in. in size and the face of all cards is alike (Fig. 1). Different color card stock is used to prevent mixing of cards in the different files. Assignment and office copy cards are ruled on the reverse sides (Figs. 2 and 3). The other two cards are blank on the reverse.

Each maintenance card, on its face, gives a brief listing of the operations to be performed at one time by a mechanic or the operator on one structure or piece of equipment. That is, one card lists the work to be done monthly for one piece of equipment by mechanics, while other cards list the work to be done quarterly, semi-annually, annually or whenever. Another group of cards similarly lists the work to be done by the operator on the same piece of equipment. A third group of cards may list the work to be done on the same equipment by semi-skilled utility workers; each card, again, listing only work to be done at one time.

The "work to be done" and the "frequency" for doing the work are determined by a study of preventive maintenance operations required by the equipment as previously discussed. An example of this procedure is given in Table 1.

The "work by" space is filled in by making a scheduled pre-assignment to a designated classification of individuals determined to have the skill and the time for doing the work. Operators of equipment usually have the time and ability for routine lubrication, clean-up and maintenance of a state of good order. Where dismantling or machining may be required, the operator does not usually have the proper skill or time to perform the work, and assignment is scheduled to mechanics. When operators do not have time for the work to be done and where a high degree of skill is not required, assignment is then scheduled to semi-skilled utility men.

Actual assignment of work to a designated individual is made at the time the work becomes current, as discussed later. This method of assignment allows the fullest, most flexible use of labor available.

The "time" for performing preventive maintenance operations is based on the service schedule of the equipment, the amount of other work scheduled in the same period, climatic conditions if outdoor work is involved, the available labor in various periods of the year and so on. When the frequency for doing the work is daily, the time for doing the work may be first, second or third shift. When the frequency for doing the work is weekly, a certain day of the week may be indicated. When the frequency is monthly, the "time" space is marked "first week," or "second week" or whatever. When the frequency is less often than monthly, the time is indicated by the month or months in which the work is to be done. For example, a quarterly frequency card might have the time indicated as "Feb., May, Aug., Nov."

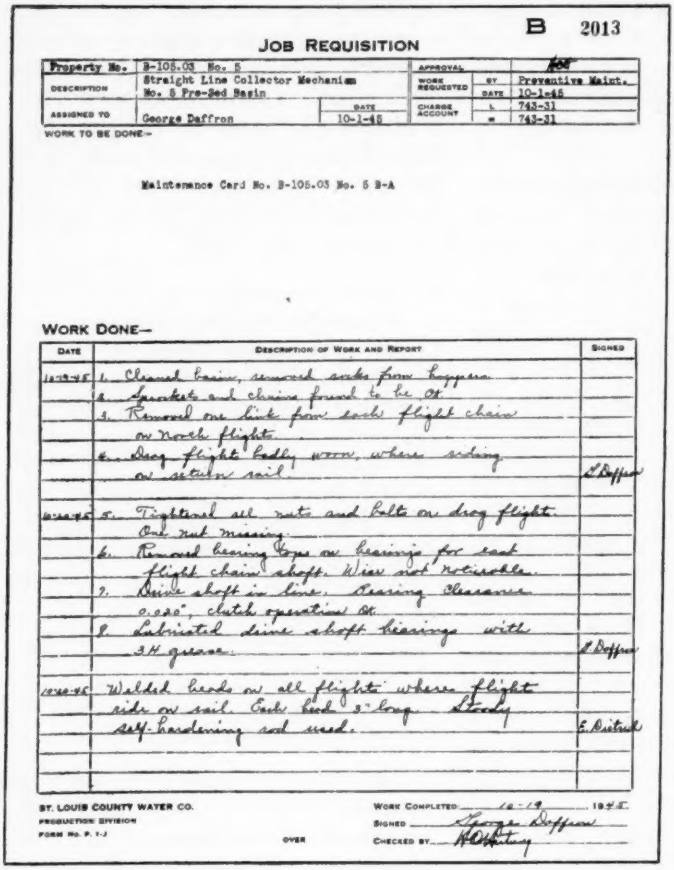
The "property number" and "description" identify the equipment upon which work is to be done. Since for each piece of equipment there are separate cards for each frequency at which work is to be done and for each class of individuals doing the work, there will be usually more than one card with the same property number and description.

The card number differentiates between the cards having the same property number and description. A hyphenated number system is used. The first part of the number is the same as the property number. Next is a letter designating the class of individual doing the work. The last letter designates the frequency at which the work is to be done. For example, C-301-M-Q is a card listing work a mechanic is to do quarterly on chemical building equipment number C-301; or C-301-C-A is a card listing work to be done by a chemical building operator annually on the same equipment. The following letter designations are used in numbering maintenance cards:

B—Basin Operator
C—Chemical Building Operator
D—Booster Station Operator
E—Electric Pumping Station Operator
F—Filter Building Operator
I—Intake Operator
M—Mechanic
O—Operations Supervisor
U—Utility Maintenance Foreman
W—Weekly
M—Monthly
Q—Quarterly
A/2—Semi-annually
A—Annually
2A—Every Other Year
3A—Every Third Year

The "account number" for labor and material insures proper co-ordination of preventive maintenance with cost accounting practices. Then, too, the account number will prevent errors when charging material and pay roll time against the proper accounts.

The copies of the maintenance cards required for the four records of the preventive maintenance program are made from a single typing on a "ditto" master sheet. One card is made for the Work Reminder File, a second card for the Current Work File, a third card for the Property Maintenance Directory and a number of additional cards equal to the number of times the work is performed each year (except cards marked "monthly," "weekly" or "daily," of which only one copy is needed) for the Calendar Maintenance Directory.



B 2013

JOB REQUISITION

Property No.	B-105.03 No. 5		APPROVAL	
DESCRIPTION	Straight Line Collector Mechanism No. 5 Pre-Sed Basin		WORK REQUESTED BY	Preventive Maint.
			DATE	10-1-45
ASSIGNED TO	George Daffron	DATE 10-1-45	CHARGE ACCOUNT L	743-31
			M	743-31

WORK TO BE DONE—

Maintenance Card No. B-105.03 No. 5 B-A

WORK DONE—

DATE	DESCRIPTION OF WORK AND REPORT	SIGNED
10-19-45	1. Cleaned basin, removed rocks from hoppers	
	2. Sprockets and chains found to be OK	
	3. Removed one link from each flight chain on North flights.	
	4. Drag flights badly worn, where riding on return rail.	G. Daffron
10-20-45	5. Tightened all nuts and bolts on drag flight. One nut missing.	
	6. Removed bearing caps on bearings for east flight chain shaft. Wear not noticeable.	
	7. Drive shaft in line. Bearing clearance 0.020", clutch operation OK.	
	8. Lubricated drive shaft bearings with 3H grease.	G. Daffron
10-20-45	Welded beads on all flights where flight rides on rail. Each bead 3" long. Stoody self-hardening rod used.	E. Dietrich

ST. LOUIS COUNTY WATER CO.
PRODUCTION DIVISION
FORM NO. P. 1-J

OVER

WORK COMPLETED 10-19 1945.
SIGNED George Daffron
CHECKED BY H. O. Hartung

FIG. 4. Face of Job Requisition

Work Reminder File

The Work Reminder File is a rotating calendar file. The assignment and office copy cards in this file are filed by the time the work is to be done. This file indicates when certain preventive maintenance operations for specific equipment have been scheduled and are due. Each time the maintenance operations have been completed, the companion cards referring to such operations are shifted forward in the Work Reminder File to the date they are to be done next.

The assignment cards in the Work Reminder File are used as work assignment orders. When the work listed on an assignment card becomes due, the card is assigned to an individual in the class shown under "work by" as his work assignment. Except for new employees, the listing of work to be done is sufficiently explanatory that work can proceed without further instructions. A new employee will have to refer to the plant "Manual of Standard Practices" to obtain full instructions.

When the work has been completed, the reverse side of the assignment card (Fig. 2) is dated and initialed by the person doing the work, and a brief report is written. After the clerk has recorded the completion data on the reverse side of the office copy card, both cards are then returned to the Work Reminder File, to be regrouped under the date when the work is next to be repeated.

A job requisition form (Fig. 4) is part of the maintenance card assignments to almost all individuals except shift operators. This form allows the writing, when necessary, of a more detailed report concerning the mainte-

nance performed on equipment. It also becomes a pay roll time sheet for the men engaged in the work.

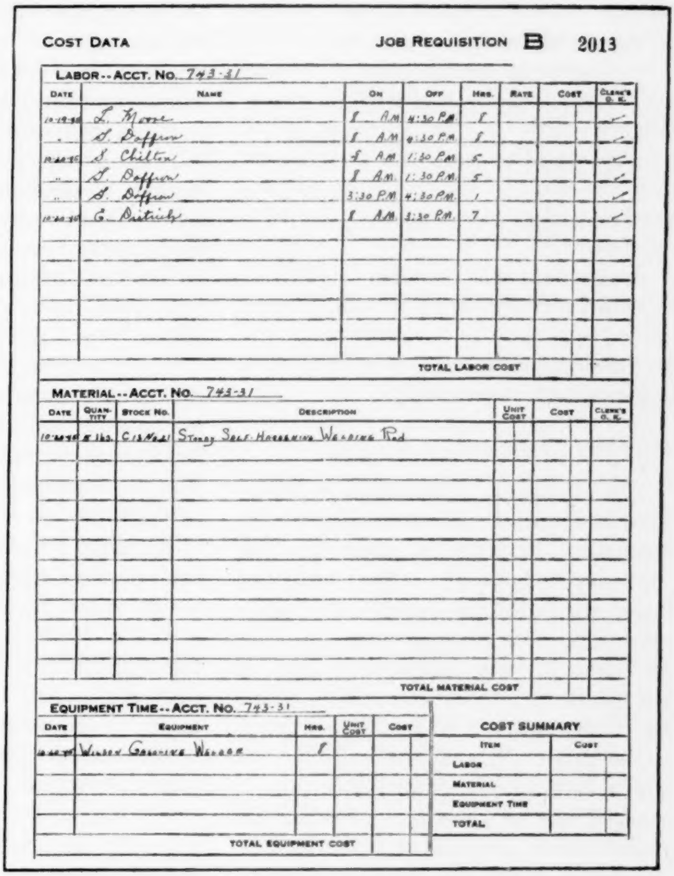
When the job requisition is approved, it then becomes the mechanic's authority to withdraw supplies and materials required from stores. Material withdrawn from stores is listed on the reverse side of the form (Fig. 5) by the stores-keeper.

The completed job requisition becomes a part of an over-all historical and cost record of maintenance given equipment. It is filed for future reference and study as a part of the equipment data and records in the folder for the piece of equipment involved.

Job requisition forms are not usually attached to card assignments to shift operators. The preventive maintenance scheduled to these men is of the "keep clean" and "inspect for proper operation" type, for which storehouse materials are not required nor a detailed report necessary. Then, too, the pay roll time for operators is always charged to a single operation account, and a breakdown of time is not required.

Current Work File

The Current Work File is the office record of preventive maintenance work, assigned and in progress. When the work assignment is made from the Work Reminder File, assignment data are noted on the reverse side of the office card. This card is then filed under the department and the man's name noted in the Current Work File. After completion of the work, when the assignment maintenance card is returned, the office copy card is taken from the Current Work File and attached to the assignment card in the Work Reminder File for use at a later date.



COST DATA — JOB REQUISITION B 2013

LABOR--ACCT. NO. 743-31

DATE	NAME	ON	OFF	HRS.	RATE	COST	CLERK'S O. K.
10-19-45	L. Moore	8 A.M.	4:30 P.M.	8			✓
"	S. Doffrow	8 A.M.	4:30 P.M.	8			✓
10-20-45	S. Chilton	8 A.M.	1:30 P.M.	5			✓
"	S. Doffrow	8 A.M.	1:30 P.M.	5			✓
"	S. Doffrow	3:30 P.M.	4:30 P.M.	1			✓
10-20-45	G. Dietrich	8 A.M.	3:30 P.M.	7			✓
				TOTAL LABOR COST			

MATERIAL--ACCT. NO. 743-31

DATE	QUANTITY	STOCK NO.	DESCRIPTION	UNIT COST	COST	CLERK'S O. K.
10-20-45	8 lbs.	C13No21	Stoody Self-Hardening Welding Rod			
			TOTAL MATERIAL COST			

EQUIPMENT TIME--ACCT. NO. 743-31

DATE	EQUIPMENT	HRS.	UNIT COST	COST
10-20-45	Wilson Gasoline Welder	8		
	TOTAL EQUIPMENT COST			

COST SUMMARY

ITEM	COST
LABOR	
MATERIAL	
EQUIPMENT TIME	
TOTAL	

FIG. 5. Reverse of Job Requisition

The Current Work File serves, first, as a check on lost or misplaced assignment cards while these cards are in the hands of operators or maintenance men to whom they were assigned. An undiscovered loss of an assignment card would cause an interruption in the scheduled maintenance for that equipment until the loss is discovered; such an interruption might be serious.

The Current Work File also readily shows the volume and the nature of the work currently assigned to each individual involved in carrying out scheduled preventive maintenance. The file is helpful when assigning cards to various individuals to prevent uneven or impossible work assignments.

A Maintenance Planning Committee reviews weekly or oftener the maintenance cards in the Current Work File to expedite work not progressing properly and to balance scheduled preventive maintenance against available manpower.

Assignment and completion data are recorded on the reverse side of the office copy card by an office clerk before assignment is made and after work is completed, respectively.

Property Maintenance Directory

The Property Maintenance Directory is a file of maintenance cards by equipment designation which provide for easy reference to the scheduled maintenance for any equipment or property item, and when it is to be done. In addition, any assignment card in the Work Reminder File can be found by cross reference to the time work is to be done. It may be necessary to find a card when certain jobs are to be worked out of schedule, or when the maintenance schedule is to be revised.

The cards for the Property Maintenance Directory are filed or grouped according to equipment property number. For example, the several maintenance cards pertaining to a chemical feeder are grouped together and constitute a file of scheduled preventive maintenance pertaining to that particular feeder. Similarly, by looking up any equipment in the Property Maintenance Directory, a group of cards pertaining to that equipment will show the preventive maintenance that has been scheduled for that equipment and when (month or week) it has been scheduled.

Although the Property Maintenance Directory and the Work Reminder File are made up from duplicate cards, each file having the same number of cards, the arrangement of the cards in these two records gives them an entirely different use value.

The cards in the Work Reminder File are grouped by periods in which work is to be done, and not by equipment; therefore, it is difficult to find in the Work Reminder File the total maintenance planned for any particular equipment. For the same reason, the Work Reminder File does not readily reveal the time during the year that preventive maintenance is scheduled for any particular equipment. To find this information in the Work Reminder File, a thumbing through all of the cards in the file would be required.

Property numbers are assigned to each piece of equipment covered by the maintenance program. The order of equipment in the Property Maintenance Directory is by these property numbers. An alphabetical arrangement of equipment in the Property Maintenance Directory File would cause confusion, since equipment is often known by several names. For example, an alphabetical arrangement would require several listings in the Property Maintenance Directory for

TABLE 2

Specimen Page From Property Number Index

- D-300 Pumping Units
  - D-301 No. 1 pumping unit
    - D-301.01 Pump
      - D-301.01.01 900-rpm. rotor assembly for electric drive
      - D-301.01.02 1,200-rpm. rotor assembly for gasoline drive
    - D-301.02 Synchronous motor and appurtenances
      - D-301.02.01 Motor
      - D-301.02.02 Exciter
    - D-301.03 Gasoline engine
    - D-301.04 Wiring from motor and exciter to motor control panel and breaker
    - D-301.05 Couplings
      - D-301.05.01 Gasoline engine end
      - D-301.05.02 Electric motor end
      - (For piping and valves, see D-1000)
  - D-302 No. 2 pumping unit

an item commonly called injector, ejector, eductor, water pump, vacuum pump, syphon jet, or the like.

Property numbers are assigned equipment upon the basis of equipment location and usage, the number itself being an adaptation of the Dewey Decimal Classification System used in libraries. The root letter is used to identify equipment location and the root number denotes the general use or type of facility. The numbers following the decimal identify the specific equipment or part thereof. Entries from a specimen page of the Property Number Index are given in Table 2. The following is a partial outline of the location key and number system in use for identifying the property in St. Louis County Water Company's production department:

A—Inter-Building and Inter-Production Unit Services
- A-100 Electric Lines and Cables
- A-200 Water Pipelines
- A-300 Sewers and Drains
- A-400 Telephone and Communication System

B—Purification Basins and Reservoirs
- B-100 Pre-sedimentation Basins
- B-200 Weir Basin
- B-300 No. 1 Mixing Basin

C—Chemical Building
- C-100 Chemical Building and Fixtures
- C-200 Tools and Service Equipment
- C-300 Chemical Feeders

E—Electric Pumping
- E-300 High-Service Pumping Units
- E-400 Parts and Accessories Used Interchangeably on High-Service Pumping Units

F—Filter Plant
- F-300 Filters
- F-400 Clear Wells and Appurtenances
- F-500 Filter Plant Piping
- F-600 Wash Water Equipment

I—Intake Facilities

L—Laboratory
- L-100 Furniture and Furnishings
- L-900 Balances and Scales
- L-1200 Sampling Devices and Aids

S—Steam Pumping Station

U—Service Shop and General Utility Equipment

Calendar Maintenance Directory

A Calendar Maintenance Directory is necessary when there is a large number of maintenance cards in the Work Reminder File. The St. Louis County Water Company's scheduled maintenance program has over 1,000 maintenance cards. The Calender Maintenance Directory, which is composed of calendar cards, shows the scheduled preventive maintenance for each month of the year and also the work scheduled daily and weekly.

For every period in which work is scheduled on a maintenance card, a calendar card copy is placed in the Calendar Maintenance Directory in the calendar section corresponding to the time marked on the card. When work is scheduled quarterly on a maintenance card, there are four copies of the calendar card in the Directory; one copy filed under each of the four months when the work is to be done. Similarly, when work on a maintenance card is scheduled to be done semi-annually, in January and July, there are two calendar card copies in the directory, one in the January section and one in the July section.

In order to keep the number of calendar card copies in the Calendar Maintenance Directory at a minimum, only one copy of maintenance cards having a daily, weekly or monthly frequency is carried in the Calendar Directory. This copy is placed in a section designated "daily," "weekly" or "monthly"; these sections preceding the twelve sections for the months of the year.

The file of calendar cards in the Calendar Directory for any current month is exactly the same as the file of maintenance cards in the Work Reminder File; however, this is true only for the current month.

The Calendar Maintenance Directory serves two purposes. First, it provides for an even distribution of scheduled maintenance throughout the year. By reference to the directory, new preventive maintenance work can be scheduled for months least crowded with other work. The directory also allows an intelligent rescheduling of preventive maintenance assignments.

Also, the Calendar Maintenance Directory is a check against lost or misplaced cards in the Work Reminder File. Each month the cards in the Work Reminder File are checked against the cards in the Calendar Maintenance Directory. It is not uncommon to discover that a maintenance card in the Rotating Calendar File has been inadvertently grouped in the wrong month.

Maintenance Planning Committee

The routine care and handling of maintenance cards and job requisitions can be done by an office clerk. Intelligent supervision is required, however, to balance scheduled preventive maintenance against the available manpower. Then, too, for the most effective preventive maintenance program, scheduled maintenance should be reviewed prior to each periodic assignment. This is the function of the Maintenance Planning Committee.

The Maintenance Planning Committee is composed of the supervisory staff (superintendent, engineer and foremen) in charge of maintenance and operations. It meets once each week to review the state of progress of previously assigned scheduled preventive maintenance, expediting the completion of the work when necessary. The work to be done on currently due scheduled maintenance cards is checked to see that the work called for is still

proper. Then, when necessary, some maintenance cards are re-scheduled to other times so that the assigned work can be completed with the available labor.

The committee balances assigned maintenance against the available labor by assigning priority ratings to the maintenance cards as they become current. These priority ratings establish the importance and order in which preventive maintenance assignments should be worked. Then, if necessary, the least important scheduled maintenance may be re-scheduled to less frequent intervals.

An added value of the Maintenance Planning Committee is the opportunity afforded for pooling and discussing the viewpoints of the several foremen. Discussions among and with the foremen have indicated that the schedule of preventive maintenance often needs revision. Operating conditions in some instances change since the writing of the schedules. Aging equipment requires more frequent inspections. Sometimes experience shows that the original schedules call for too many or too few inspections and require revision. All of these factors prove the value of the Maintenance Planning Committee in reviewing preventive maintenance assignments regularly.

Summary

Scheduled preventive maintenance is designed to eliminate breakdowns and unplanned equipment outages and to keep equipment operating at top efficiencies. The operations comprising preventive maintenance and the frequency at which they are performed are tabulated for each piece of equipment, based on operating experience, service conditions and manufacturers' recommendations. Then, to make preventive maintenance most effective, a written program is required. The program at the St. Louis County Water Company uses cards upon which are briefed the preventive maintenance work to be done, when it is to be done and who is to do it. The assignment cards in the Work Reminder File are work reminders as well as work assignment cards. Office copy cards (similar to assignment cards, except for the ruling on the reverse side) are used as checks against lost assignment cards and make up the current work file of work which has been assigned. Additional copies of the face side of the assignment card comprise the Property Maintenance Directory and the Calendar Maintenance Directory. The Property Maintenance Directory shows the work scheduled for each piece of equipment. The Calendar Maintenance Directory shows the work scheduled for each period during the year. A Maintenance Planning Committee, meeting weekly, administers the program, and an office clerk handles the maintenance cards.

The value of the entire program has proven itself in the comparatively trouble-free operation of the purification and pumping plants of the St. Louis County Water Company. The program described is satisfactory in order:

1. To schedule preventive maintenance required by equipment on a definite periodic basis.

2. To schedule preventive maintenance work so that it is evenly distributed throughout the year.

3. To provide a simple procedure for changing the frequency or the nature of work to be done, as determined

by experience or a change in operating conditions.

4. To provide a record of preventive maintenance scheduled and preventive maintenance completed for each unit of equipment.

5. To provide a record of preventive maintenance scheduled for any time during the year.

6. To provide a means by which the cost of maintenance of equipment may be determined.

References

1. KENT, R. T. *Kent's Mechanical Engineers' Handbook III.* John Wiley & Son, New York. p. 16 (1936).
2. ———. *Kent's Mechanical Engineers' Handbook II.* John Wiley & Son, New York. p. 8 (1936).

DISCUSSION—*Vance C. Lischer*

Cons. Engr., Horner & Shifrin, St. Louis, Mo.

A preventive maintenance program designed for the orderly care of equipment in a small plant need not be complicated by extensive record forms or clerical operations. The basic principles are easily adapted to a small plant.

The forms and the clerical procedures used in the administration of the program at the St. Louis County Water Company are only necessary in a plant involving many employees and departments when the program must also serve as an aid to supervision. This need does not exist in a small plant of less than five or ten operators.

A conscientious person charged with the responsibility of operating a small water plant must recognize the need for a method of insuring continuity of operation of all equipment in his plant. Memory should not be depended on to decide when an inspection or maintenance procedure is due or exactly what is to be done or how.

No plant operator wants to be responsible for a plant in which failures continually occur. Failures are inevitable, however, if preventive measures are not taken. It seems only natural that a written scheduled preventive maintenance program should develop from this situation.

In a small plant where the employees are few in number and where the personnel are individually responsible for both operation and maintenance, the preventive maintenance program functions principally as a reminder of work to be done. The program simply consists of a group of reminder cards in a calendar file which is conscientiously followed and carefully watched to prevent the loss or misplacing of cards. This is important because, after the program is completed and all equipment covered by it, it is naturally believed that all equipment is being adequately maintained. A false sense of security will exist if cards are missing and maintenance operations are, therefore, not being done.

Basic Principles

Fundamentally the most important preventive maintenance procedures are very simple and fully within the capabilities of a small plant operator. They depend largely upon (1) cleanliness, (2) thoroughness, (3) integrity and (4) strict adherence to schedule.

Most preventive maintenance operations are cleaning operations: cleaning

the inner crevices and corners of equipment—not just the part that shows; cleaning electrical switch boxes and contacts; cleaning and flushing bearings; cleaning motor windings and commutators; cleaning chemical feeding equipment; cleaning electrical substations, removing birds' nests and cleaning and painting metal and wood surfaces subject to deteriorations. All of these simple cleaning operations will be a part of preventive maintenance when they are done according to a predetermined schedule.

Thoroughness likewise is important, since the causes of failures are so often the little things: loose bolts or electrical connections, an overloaded or oil-soaked motor, a vibrating shaft, an oil ring failing to turn. All of these require observance of small details on the part of the operator when making inspections of equipment called for by the preventive maintenance program. Too often many of these simple observations are overlooked in the hour-to-hour inspections which are properly an operator's responsibility. With these inspection items specifically listed on a maintenance card to be done at regularly prescribed intervals, there is little opportunity for such oversights.

Integrity as a basic requirement of such a program must seem obvious; however, its essentiality demands that it be emphasized here. Naturally the inspection and maintenance operations called for in the reminder system must be done. It is essential that the party assigned the responsibility know how to perform the operations. If the inspection or operation called for is beyond the capacity of the operator, outside assistance should be called in. The operator cannot have all the skills required for the complete maintenance of his plant, and he should be prepared to call in persons with the experience necessary. The lack of these skills on the part of the operator should never prevent the operations from being done. Just as an electrical motor repairman is called in to repair a burned-out motor, so should he be brought in to perform preventive maintenance operations calling for the periodic testing of the insulation of a motor or a transformer. Similarly qualified persons should be called in to interpret manufacturers' instructions where necessary and to designate the necessary preventive maintenance operations in the inauguration of the program.

Strict adherence to a calendar program is essential to a properly functioning preventive maintenance program. The important factor in a preventive maintenance program, which differentiates it from other methods of maintaining and operating a plant, is the utilization of a reminder system which calls attention to the operator of inspections and maintenance operations to be done at a definite time. The whole program fails if the schedule is not adhered to. It must be recognized that errors will be made initially in the assigning of frequencies; however, under no circumstances should the frequencies be changed unless experience definitely indicates an error.

Inaugurating a Preventive Maintenance Program

A preventive maintenance program need not be placed in effect all at once. In any plant which is functioning in its usual manner and in which those in charge are conscientious, preventive maintenance operations are probably already being done. In most cases, however, no record or reminder system is employed. To get a system started

all that is necessary is to secure convenient-sized cards (the 5-in. by 8-in. size is suitable) and to begin tabulating inspection and maintenance operations on the cards. When the operations called for are done according to the predetermined schedule, preventive maintenance is the result.

Each card should be made out for an individual plant unit and for the operations to be done on this individual unit at the same time and frequency. Until all the operations and inspections are handled through the preventive maintenance program, the cards can be used in parallel with whatever method of equipment care is in practice in the plant.

Since each card must refer to a single unit of plant equipment and also should include all work to be done at the same time and frequency, the making out of a preventive maintenance card for any unit of the plant involves initially making an inspection of the unit and listing all required maintenance operations which are readily apparent. After the inspection is completed and a listing tentatively made, it should be checked against the manufacturers' instructions. If these instructions are not available in the plant records, they should be obtained from the manufacturer. Army Technical Manual TM 5-661, entitled "Inspection and Preventive Maintenance Services for Water Supply Systems at Fixed Installations," (1) will be helpful. It may be necessary to secure the services of a mechanical or electrical engineer to designate maintenance operations. In this manner, after all equipment in the plant has been reviewed, a comprehensive maintenance program will have been created.

A preventive maintenance program is seldom a finished product at its inception. Experience in the operation of the plant will suggest many changes or additions. The operator should, therefore, always be on the alert for changes and additions which will be helpful to the program. Whenever a failure occurs, a thorough investigation probably will indicate important inspection and care operations to be added. The operator should make a note of all unusual occurrences which can provide a basis for changes and additions to the program.

Examples of Preventive Maintenance

To illustrate the practicability of preventive maintenance and how it guards against possible outages and reduces costly repairs, the following examples of preventive maintenance operations are given:

Wear and Abrasion

Much of the equipment used in a water plant is subject to wear and abrasion. Periodic replacement of worn parts or metal is necessary. Only through scheduled inspection can the progress of wear and abrasion be followed so that the corrective measures can be applied before the equipment is worn beyond repair and the maximum life obtained from the equipment. A preventive maintenance program answers this need.

Lime slakers, which are usually subject to abrasion, sometimes have renewable liners. These must be replaced before the body of the slaker is worn through or costly repairs will be necessary.

Chemical pumps, likewise subject to abrasion and corrosion, require periodic inspection to give continued, dependable performance.

Clarifier flights and rails can be hard-surfaced by welding while there

is still sufficient metal left to be welded to, if periodic inspections have indicated the proper time to make the repairs.

Gear teeth on flocculator drives can also be hard-surfaced by welding, if they are observed through the functioning of a preventive maintenance program.

Centrifugal pump sealing rings can be replaced or the original fit restored by welding before excessive loss in efficiency takes place if the unit is dismantled regularly and clearances measured. A preventive maintenance program should call for the dismantling of centrifugal pumps at least every two or three years.

Testing of Equipment

A preventive maintenance program should schedule testing of plant equipment and describe the method for making the test in detail, step by step, on the maintenance card. The results of these tests will point out defects and often result in savings in operating cost.

All pumping units should be tested at least annually. Pumps can be tested by a drop in the clear well or by means of the plant flow meter if the plant is so equipped. The flow meter itself should be periodically checked.

Prime movers and power plants should also be checked by fuel and steam measurements and by taking indicator cards on reciprocal steam engines. The input to an electrical motor should be checked at the time the load is measured and efficiencies calculated. Variations from the specified original performance are cause for thorough investigation.

Flow meters and rate controllers on filters can be checked by a drop test. Pressure gages should be calibrated regularly.

Electric relay settings and electrical instruments should be checked not less frequently than every five years.

Idle or Standby Equipment

Standby equipment or normally idle units particularly need the scheduled attention that a preventive maintenance program can provide. The readiness-to-serve of such units is often taken for granted and, if they are not operated regularly, they may fail to function when an emergency requires that they be placed in service.

Included in the equipment under this heading are: valves; spare pipelines; standby pumps, motors, and power plants; fire fighting apparatus; emergency chlorination equipment; and reserve repair equipment, such as contractors' pumps, air compressors, pipe cutters, tapping machines and light plants.

Cleaning

As stated before, cleaning operations are an important part of preventive maintenance. Some cleaning operations not likely to be thought of in connection with preventive maintenance are given below. Unless these items are scheduled they probably will be overlooked altogether until a failure occurs.

1. Cleaning boiler flues.
2. Cleaning switch and fuse boxes.
3. Blowing out motors.
4. Cleaning lighting fixtures.
5. Cleaning chemical solution lines.
6. Cleaning electrical substations.
7. Cleaning laboratory apparatus such as stills, hot plates, refrigerators, incubators, water baths, autoclaves and optical instruments.

8. Cleaning shop equipment, tools, electric drills, and so on.

9. Cleaning scale and sediment from conduits and flumes in the purification works.

10. Cleaning the fuel system of automotive equipment and other units having internal combustion engines.

A preventive maintenance program aids adherence to schedule for any function which the operator may desire to include. Reminder cards for various other purposes can be carried along with the regular maintenance cards. The system will eventually become the nerve center which will keep the organization alert and the plant healthy.

Reference

1. War Dept. Technical Manual TM 5-661. Inspection and Preventive Maintenance Services for Water Supply Systems at Fixed Installations. U. S. Govt. Printing Office, Wash., D. C. (1945).

DISCUSSION—*Paul Weir*

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It has been said that "an idle mind is the Devil's workshop." This is particularly true of an unco-ordinated maintenance program, especially when dealing with intricate and expensive water works equipment. The author's definition of scheduled maintenance as "the practice of preventive maintenance" is justly founded. Proper inspection and repair schedules insure continuity of service, efficient operation and protracted utilitarian life for all equipment.

Those in the water supply field have but one commodity to sell their customers. That commodity is *service*—1,440 minutes a day, 365 days a year. The only way they can accomplish this herculean task is to maintain all functional operation at a maximum efficiency. The proverbial "stitch in time saves nine" haunts every water supply operating schedule.

An orderly and effective maintenance program in all plants, irrespective of size, should be as consistently and intelligently administered as regular payments on a bond issue or bank note. A planned maintenance schedule permits one to select the time and personnel for accomplishing a given task under ideal conditions, whereas breakdowns are usually periods of confusion and necessitate temporary expediencies and abnormal labor costs. Planned maintenance also permits personnel greater opportunities for intimate study and contact with equipment. This results in a familiarity with equipment which instills confidence and self-reliance in an emergency.

Most men discharge their daily maintenance responsibilities along rather well-defined channels. When they attempt to carry too many details "under the hat," however, their capacity for accuracy and continuity diminishes. It is therefore essential that schedules be cataloged into concise operational programs. This may be accomplished by brief notations on a daily reminder calendar or an extensive card index file. Both insure a sense of propriety in operating personnel and depend on consistent application for success. Obviously, details of a preventive maintenance program depend upon the needs of the individual system. Experience has indicated that it is best to start out with a relatively simple plan

and then elaborate as the need is indicated. Operating personnel must be sold on the plan—step by step—and after the program gets off to a good start, sound suggestions for improvement will come from the working force.

The authors have promulgated a most commendable scheduled maintenance system, based on intelligent and practical application. The entire water supply profession is indebted to these gentlemen for their scholarly contribution, and it is significant that the Armed Services adopted their system of scheduled preventive maintenance during World War II.

In 1932 Linn H. Enslow presented a paper at the Southeastern Section Meeting depicting the value of procuring basic operating data and suggesting a simple indexing system (1). It was a trip through a large southern sugar refinery, however, that first impressed this writer with the feasibility of planned maintenance. For example, all exposed machinery in this plant was stenciled to indicate lubricating schedule, including type, volume and frequency. A simple loose-leaf indexing file, used in scheduling all maintenance and repairs, produced one of the best examples of "good housekeeping" that the writer has seen in a pure food plant.

The system of maintenance at the Atlanta Water Department was largely of the simple daily reminder calendar type until a visit to the St. Louis County Water Company revealed the merits of a more comprehensive filing and indexing system. Since that time, the department has continued to improve its program until at present each plant uses a Rand Card Book File System, consisting of 54 pockets with 8-in. by 5-in. cards and a color index scheme. A master Rand Card Book File System is kept in each operating office and consists of 102 pockets with cards and a similar color index scheme. A loose-leaf operating manual data book, with celluloid sheet protectors, is maintained in conjunction with each index file system in order that specific information may be obtained on each subject.

The enthusiasm which the operating personnel of the Department has displayed in building this program is gratifying, and alone compensates for the time of compilation and small cost of material involved. The subject of planned maintenance stimulates lively discussion at any Coca-Cola hour and is a source of satisfaction and value to all. No additional personnel is necessary to carry out this program—in fact, existing personnel learns how to do a good job better. It has been found that the systematic scheduling of the maintenance programs extends utilitarian life of equipment, reduces costly and "after midnight" breakdowns and promotes co-ordinated plant operation.

The St. Louis County Water Company's scheduled maintenance program is unreservedly recommended for the successful and economical operation of a water supply system.

Reference

1. Enslow, Linn H. J. Southeastern W. W. A., p. 75 (1932).

Army Water Supply in World War II

By W. A. Hardenbergh

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Presented on May 8, 1946, at the Annual Conference, St. Louis, Mo.

At the end of the war there were more than a thousand water systems serving troops in the United States, and a far greater number overseas. These varied in type from modern rapid sand filters to improvised tanks and chlorinators and in size from perhaps 500 to 5,000,000 gpd. The problems of building and operating these systems and controlling the quality of the water they furnished were complicated by many factors—the speed with which construction was required, the limitations of shipping, the shortages of material, the scarcity of trained operators, and the decentralization and dispersal of authority characteristic of and probably essential to the army. Despite all these obstacles, the army had safe water; there was no epidemic of water-borne disease. In fact, our army had the lowest morbidity rate that any army has ever had in any war, and this would not have been possible without uniformly safe water.

According to Army Regulations, the Medical Department is responsible for recommendations covering all factors affecting health. Translated into actual water supply practice, this means that it must see and know all about those factors in water procurement and purification that may adversely affect the health of the troops. These responsibilities of the Medical Department for water quality were delegated to the Sanitary Engineering Division of the Preventive Medicine Service, along with the responsibility for all other sanitary engineering matters. The Sanitary Engineering Division was also the Medical Department organization in charge of most of the activities of the Sanitary Corps, which consisted of about 2,900 non-medical technical officers in grades from lieutenant to colonel. It was responsible for a wide variety of sanitary engineering work, including—in addition to water purification—waste disposal, insect and rodent control and innumerable military applications of these basic functions.

The complexity of an organization as large as the army is exemplified by the assignment of the design, construction and operation of water supply facilities to the Corps of Engineers. In the United States, the Construction Division designed and built the plants, and the Repairs and Utilities Division operated them. Overseas water supplies were built and operated by organizations too numerous to mention.

Water Supply for U.S. Camps

Water supply was usually an important and often a deciding factor in locating a major training camp. When-

ever possible, water was purchased from adjacent municipalities in order to save construction materials and speed completion of the camp; but there were relatively few instances where this could be done. To provide for a 35,-000-man camp meant a daily draft of 3 mgd., with peaks up to 5 mgd. Allowance had to be made, too, for the increase in city population due to the establishment of the camp; generally this amounted to 30 to 40 per cent of the camp population. The author reviewed the preliminary reports and plans for nearly all of the major camps and found only a few places where municipalities had enough water over and above their own needs to supply a large camp. As a result, most of the supplies for large camps had to be developed by the army.

It is obvious that the safety and sufficiency of any water supply depend upon proper execution of all the three functions for which the Corps of Engineers is responsible. A water supply installation that is improperly designed, carelessly constructed or inexpertly operated is not likely to produce safe water all of the time. Proper recommendations may remedy incorrect operating procedures, but water supply systems are permanent structures; defects built into them may nullify the best of operations and can be eliminated only at considerable effort and expense. Therefore, the first step by the Sanitary Engineering Division toward the control of water quality was to establish, in co-operation with the Corps of Engineers, standards of design based on good water supply engineering practice. These standards were generally incorporated in all fixed army water supply installations and were reflected in the fine record for water quality that the army made.

The frantic haste that was necessary and that characterized the construction of our army camps in 1940 and 1941, resulted in the presence of numerous serious sanitary defects in water supply and purification plants. This condition was the fault of no one; it was a natural consequence of our lack of preparedness. The shortage of personnel and the limited time available prevented the division from maintaining a sanitary engineer at each camp to supervise construction and make sure that each installation was perfect from the sanitary point of view. In order to locate and correct these defects, the Sanitary Engineering Division, in August 1941, issued a directive requiring that all plants furnishing water to army personnel, whether army-owned or not, be surveyed by a qualified sanitary engineer. The initial survey resulted in many hundred corrections and proved so valuable that thereafter these inspections were made annually.

Another problem arose as the mobilization tempo was stepped up, and camp populations were increased far above design bases by double-bunking and the use of tentage to house troops. This necessitated some rationing of or restriction on the use of water pending the provision of additional supply and treatment facilities. The problem was especially serious with purchased supplies, since cities were not normally able to enlarge their plants quickly. As a result of this experience, all army water supplies built thereafter were designed with a wider margin of extra capacity—as much as 100 per cent for very small plants, but generally based on army experience and judgment concerning the probable growth of the various types of camps. Also, more attention was given to devices which would

limit the amount of water used; for example, automatic flushing devices were replaced with manually controlled equipment.

The high command of the army was concerned, during the early years of the war, with the possibility of sabotage at army camps. Since it appeared that water supplies were most vulnerable to this type of attack, various measures were adopted which would minimize the potential danger. Among these measures was the requirement that the water be chlorinated to provide a residual of 0.4 ppm. In the application of this requirement, a great deal of opposition arose. In addition to the protection against possible intentional contamination, however, the end results from a sanitary viewpoint were most satisfactory, for the effective chlorination of army water supplies was a highly important factor in maintaining safe water at all installations. The skilled and faithful operation provided by the Repairs and Utilities Division of the Corps of Engineers was another essential element in obtaining and maintaining a high standard of water quality.

The results of the water quality control program in the United States are of interest. Whereas non-potable samples averaged from 13 to 15 per cent during 1941 and early 1942, they were reduced in 1943 to around 2.5 per cent, and in 1944 and 1945 to about 1 per cent. These results were based on a sampling program of about 20,000 samples per month. No outbreak of water-borne disease resulting from use of an army-owned or army-operated water supply was reported. Early in the war, there were some outbreaks due to careless handling of purchased supplies, but even these were infrequent and affected only small numbers of troops.

Another problem involving water supply in the United States was the wholesale use of hotels to house troops. The resulting loads on the water and waste disposal systems greatly intensified the hazards from defective plumbing and cross-connections. All hotels used by the army were surveyed by trained sanitary engineers and defects found were speedily corrected—before the troops moved into the building if the hazards were serious. Essentially the same problem arose in the use of colleges by the A.S.T.P. and the same corrective procedures were followed. Port and ship water supply presented an exceedingly difficult problem that was never fully solved, though many marked improvements were made in both ship and port supplies, and no serious water-borne epidemic involving army personnel was reported. Safeguarding the water supplies of essential industries was, in part, a function of the Sanitary Engineering Division, and about 25 sanitary engineers were engaged in this work.

Fixed Installations Overseas

It is difficult to classify overseas water supplies arbitrarily, as fixed, semi-permanent or temporary, since the classification frequently changed with military conditions. Our overseas air fields, our main bases and many of the sub-bases, however, were relatively permanent. Where local water supplies were available, these were used during the early stages, and chlorination was practiced to assure a safe water. In many places, these local supplies soon became inadequate, because of the high rate of consumption, and the Army had to construct its own systems. Wherever possible, wells were used, and the water chlorinated. If ground water was not available, sur-

face supplies were developed and usually the water was filtered. In Great Britain, existing supplies were used almost exclusively; in the Southwest Pacific, most of the water supply systems had to be constructed. In the other theaters, practices varied according to conditions.

In general, the same procedures were employed as in the United States: inspection by a qualified sanitary engineer to determine the type and location of defects; correction of these defects; and supervision of operation, with chlorination to insure a safe quality of water. Although bacteriological data are not plentiful, except from a few theaters, all of the information at hand indicates that the quality of the water provided by our fixed installations overseas was but slightly, if at all, inferior to the water supplied to our troops in this country.

Field Water Supplies

There was an ample background of sanitary engineering knowledge available for guidance in the design, construction and operation of water supplies to serve our camps in the United States. The reverse was the case with field water supplies, especially in overseas operations. The American Army entered World War II without adequate organization or equipment to provide safe water under field and combat conditions. In fact, army thinking as regards water supply for troops in the field had not progressed beyond World War I; and, in the early days of the war, those responsible for this condition were very unresponsive to suggestions for change.

Coupled with these inadequacies in organization and equipment was our lack of knowledge of overseas conditions. No one knew how serious various unfamiliar water-borne diseases, such as amebic dysentery, would be, nor what to do if they were serious. There were no data in engineering texts to indicate the chlorine dosage and the contact period required to destroy amebic cysts. Nor were there data on the method of operating field filters to remove the cysts. Some medical texts were available which indicated that as much as 75 to 100 ppm. of chlorine might not be cysticidal.

Army water supply equipment available to the army included the Lyster bag, a 36-gal. container of rubberized canvas; the portable sand filter; and the mobile sand filter. The portable filter has about 1.5 sq.ft. of filter surface and is normally operated at from 15 to 20 gpm. The mobile filter, which has a filter area of about 10 sq.ft., is normally operated at about 100 gpm. The Lyster bag is issued to all troops at the rate of one to each 100 men. The portable filter is part of the equipment of the Water Supply Section of the Engineer Regiment or Battalion; normally four filters are assigned to each division, but this may be varied according to local conditions. The mobile filter is generally assigned to a special unit—the Engineer Water Supply Company.

There was no canteen sterilizing agent. Neither the portable nor the mobile filter, when operated in accordance with army directives, would remove amebic cysts; and it was questionable if they would produce safe water under even ordinary conditions. Coagulant was added as the water entered the filter shell, with the result that the filter merely acted as a strainer and post-coagulation frequently occurred in the finished water tank. Since ammonia alum was used, all chlorine was in the form of chlora-

mines; the water was frequently turbid or contained organic matter. As many as 50 per cent of the samples taken from water points were non-potable when this method of operation and high filter rates were used.

Lyster bag chlorination provides about 2.4 ppm. of chlorine and is a safe means of combatting bacteria, provided the water is fairly clear. There was a serious doubt whether this procedure would be effective against amebic cysts, and later tests showed that it was not. Thus the army approached extensive operations overseas without a single method or piece of equipment that was effective against amebic dysentery, or perhaps against other water-borne diseases as well.

Research was started on these problems and a beginning was made on obtaining data on overseas water installations and sources of supply. Member companies of the A.W.W.A. contributed a great deal to our knowledge of foreign water installations. Later, these data were supplemented from many other sources, so that we generally had information that was marvelous in its completeness.

In the selection of a canteen sterilizing agent, every known disinfecting compound that appeared to have promise was investigated. Halazone was finally adopted; it was not ideal, but it was effective under the great majority of conditions, and it served us well. Research was initiated to develop a better agent, but none was available in time for wide application in the field. It is a long distance from the laboratory to the field. For instance, a canteen sterilizing agent must have certain characteristics—quick solubility, stability and cysticidal value, to mention only a few—and it must be readily adapted to large-scale manufacture. The finished product must be teste for stability by storage under sever conditions of temperature and humidit When these tests have been passe satisfactorily, and the product has bee standardized and ordered, all existin directives on methods of using cantee sterilizing agents must be reviewed an where necessary modified; and ap-plicable training programs must b changed. Then the supply lines ca begin to fill. A new agent must pos-sess a marked superiority to justify it use under wartime conditions. Es-sentially the same procedure in re-search, development, testing and stand-ardization must be followed with a new equipment.

New operating methods, based o recognized water works practice, wer developed for the portable and mobil filters. These methods provided fo coagulation, sedimentation and pre-chlorination, followed by filtration at greatly reduced rate—not over 6 gpm per sq.ft.—and by post-chlorinatio when needed. A long series of tests in-dicated that these procedures woul guarantee a safe water under prac-tically all field conditions. It was long time, however, before the Engi-neer School and Ground Forces Com-mand adopted this procedure as stand-ard. Largely because of this delay, th diatomite filter was developed. It rep-resented a marked advance in field wa-ter purification equipment because was lighter and easier to handle, and proved satisfactory even on the ver difficult water our troops had to use i China. Other developments include the pad-type filter and a highly ef-ficient distillation unit. This develop-mental work was carried on by th Water Equipment Laboratory of th Corps of Engineers at Fort Belvoi Va.

An approach was also made toward developing treatment procedures that guaranteed safe water while permitting the use of existing army equipment. Super- and de-chlorination appeared very effective and perhaps should be made standard army field practice. Some of our engineers reported a good degree of control of the final residual with sodium thiosulfate applied by means of hypochlorinators.

Army water supply organization was, at the best, only adequate in those places where the proportion of combat troops was large, as in Europe and the Southwest Pacific, but even there it could not be termed satisfactory. It was totally inadequate in those areas, like Burma and India, where the great bulk of the troops was composed of supply units. Supply troops have no basic water procurement and purification equipment and no personnel charged with or trained in water supply. Even when water installations were improvised and men were trained as operators, there was no assurance that they could be retained on the job; in fact, it was unusual if they did remain for any appreciable length of time. The War Department policy of using natives for handling water and also food contributed to the difficulty, as they had no knowledge of sanitation. Recontamination of water was common, especially where there was no chlorine residual.

There were also some occasions when well-trained sanitary engineers refused to approve municipal supplies for use. Such disapproval was perhaps based on minor defects that could have been corrected quickly, or on unfavorable bacteriological results that could have been reversed by adequate chlorination. Often this forced the Corps of Engineers to draw and treat water, with their inadequate equipment, from heavily polluted streams when a potentially very satisfactory supply was already at hand.

These various happenings reflect the unsatisfactory organizational policy of the army in regard to field water supply. Divided responsibility, lack of planning and inadequate organization resulted in many difficulties and problems in the field. That most of these were overcome and that the army generally had safe water is a tribute to the sound technical training and good sense of the young men of the Sanitary Corps and the Corps of Engineers. There were very few cases where water could be shown to be the medium of disease spread. Bacteriological results, where these were available, proved this. Filtered and chlorinated supplies in Burma showed only 2.5 per cent of the samples to be non-potable. The Third Army in Europe virtually eliminated non-potable samples at its water points. In the South and Southwest Pacific, non-potables rarely exceeded 2 per cent.

Research and development are essential to improve army methods and equipment for water supply. The problems of amebic cysts need more definitive study. About the time that the army felt it had solved the cyst problem, an investigator claimed that he had established, through sub-culturing, that chlorine did not destroy cysts. He gave no details of his work, but his claims are disturbing and his work should be verified or disproved. More research is needed on methods of treating water to prevent the spread of schistosomiasis and hepatitis; and there are other diseases, aside from the commonly known ones, which may be spread by water and which should be investigated.

Work should be continued on canteen sterilizing agents, especially those of the super- and de-chlorination type, on small filters of the pack type, and on larger filters which should be suitable for use for a variety of conditions and volumes of water. Equipment also needs study and improvement. The canvas tank, for example, lasted only two to three months in some climates; and there has never been a really good water container.

The importance of knowing where to get water when troops go ashore or enter foreign territory cannot be overstressed. The army unit charged with water intelligence did a remarkable job. In making plans for invasion, it was essential to know a good deal about the water resources of the area, whether ground or surface water would have to be used, the depth to ground water, the soil formations, the amount of surface water present, and as much as possible about its characteristics. If reliance is to be placed on ground water, well rigs, pumps and tanks must be put ashore early, and these must be of the proper type and adequate in number. If surface water is to be used, troops must be supplied with filters, alum, soda ash, activated carbon and chlorine compounds. This information has to be available months in advance, in order that the proper type and amount of equipment and the men to operate it are on hand when the troops go ashore. These water intelligence studies ought to be continued and expanded, and co-ordinated with medical intelligence studies to give a complete picture on which to base our army water supply planning.

Army water supply needs to be brought up to date and reorganized with the lessons of World War II as a basis. But this alone is not enough. In order to assure continued progress and development, keeping step with advances in the civilian field, it is necessary to establish a close working relationship between those in the army responsible for development of equipment and methods, those responsible for army organization and policy, and the water works industry.

The problems that have been outlined here were largely the author's personal responsibility during the war, and he has reported them from that viewpoint. Except through reports and occasional personal visits to the field, the author was not familiar with the detail application to specific problems. That was the job of the men in the field; his was to plan and to make it possible for the men in the field to work as effectively as possible. In doing this, it should be clearly understood that the Surgeon General's Office never restricted his authority, nor withheld its full support. The problems that arose were inherent in the defects of army organization and were the result of lack of foresight, inadequate advance planning, the inflexibility of army procedures and the necessarily large degree of decentralization of authority to overseas commanders. In the end, these were largely overcome by the skill of our engineers, and the army was supplied with uniformly safe water. But even this happy ending does not lessen the desirability of better planning and preparation for the future.

Enemy Water Supply Equipment

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DURING World War II, intelligence teams operating under "G-2" were active in both combat theaters on all fronts. The mission of these teams was to examine carefully all new types and models of captured enemy equipment, and to evaluate carefully the equipment so that any required countermeasures could be initiated immediately. In this manner, allied forces were constantly kept advised of the tools of war in the hands of the enemy.

Following the cessation of hostilities, other special teams were organized and sent into the occupied countries to investigate thoroughly specific classes of equipment and the methods of their production. On the basis of preliminary reports and evaluation of equipment captured during the course of military operations, these teams were also assigned the task of tracing the development, manufacture and application of specific equipment or of methods used when no special equipment was involved.

From May to July of 1945, a team representing the Intelligence Division, Office, Chief of Engineers, made an extensive investigation covering German engineering equipment. On this team was Lt. Herbert E. Hudson Jr., representing the Engineer Board, which is charged with the conception, development, perfection and testing of all Army Engineer items of equipment. Lt. Hudson gathered information on research and development as conducted by the Germans on military water supply equipment; specifically with reference to methods of treatment and purification used in field water supplies, methods and treatment evolved for use in removal of chemical warfare agents, methods and chemicals used in sterilizing water supplies and complete descriptions of all equipment hitherto unreported or on which information was incomplete.

In addition to information received from intelligence teams, evaluation reports were prepared by the Technical Staff of the Engineer Board, based on examination and testing of samples of captured enemy equipment.

German Army Water Supplies

The development of water supply equipment in the German Army was a Medical Department function, carried out under the immediate direction of the Institute for Troop Pharmacy and Applied Chemistry. The institute, under the direction of a Dr. Gemeinhardt, formed a part of the Medical Military Academy, Berlin, which in turn was under the authority of the Army Sanitary Inspection Organization, a branch of the Army Office. The

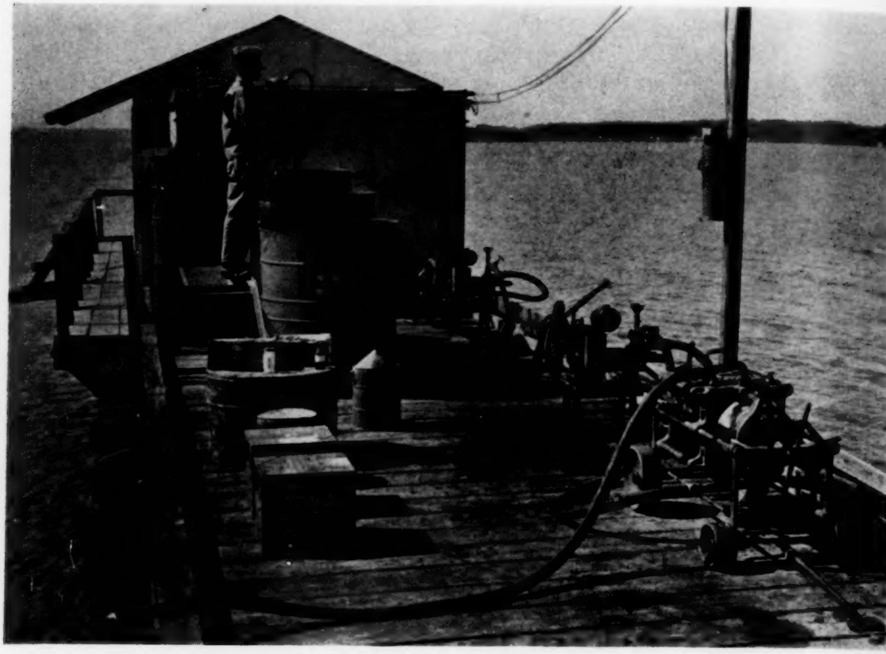

FIG. 1. Large German Seitz-Type Water Purification Unit

Institute of Pharmacology and Troop Toxicology, another part of the Academy, collaborated in the work on treatment of waters containing toxic chemical agents. Engineering details of water supply equipment were reviewed and approved by the Fortress Inspection Organization and procurement was handled by the Weapons Office.

In the course of the intelligence teams' investigation, many prominent scientists and engineers were interrogated, but broad policies and numerous details concerning water supply apparently exist only in the head of Dr. Gemeinhardt who, to date, has not been apprehended for interrogation. The German security policy that "no one shall know more than is needed in his work" seriously hampered the investigators. At nearly every target the investigators were confronted with the statement that "This is as far as our information goes; you must see Dr. Gemeinhardt for the rest."

In general, it may be stated that the actual development of German water supply equipment was carried out by the commercial companies. Principal among these were Berkefeld at Celle, which developed and manufactured water supply equipment particularly for the Luftwaffe, and The Seitz Filter Company at Bad Kreuznach, which built pad-type filters principally for the ground forces. Lurgi, basically a distributive agency with offices in Bad Hamburg and Frankfurt-am-Main, did much work on the evaluation of available carbons for their ability to remove arsenicals from water, and assisted other concerns in developing equipment for this purpose. Lurgi also developed a process of its own in

this respect, which involved super-chlorination followed by de-chlorination using active carbon.

Seitz Filters

In the field, German water supply was a troop function. Each company carried one of the small Seitz Tornister-filters. This filter consists basically of a small filter press taking eight Seitz K-5 filter pads 7.9 in. square and providing an effective filter area of 3.75 sq.ft. A small oscillating-type hand pump was secured to the filter press and the complete filter mounted on top of a box-like base in which were carried the suction hose, strainer, float and spare filter pads. No chemicals for pre-treatment and sterilization were normally supplied with the unit. Filter plates, frame and base were constructed of aluminum. In operating tests from raw water having turbidities of from 10 to 100 ppm., this unit produced turbidity-free water, with a relatively low bacteria count, at rates of from 55 to 22 gph.

A large Seitz-type water purification unit was issued to each division medical unit. This set (Fig. 1) consisted of four nestable, cylindrical tanks of light-gage steel construction used for pre-treatment; two hand-operated oscillating-type pumps; two gasoline-engine-driven centrifugal pumps; a chest containing miscellaneous hose and fittings; and a four-wheel trailer-mounted two-stage filter press. One section of the filter, using twenty Seitz EK filter pads providing a filter area of 30.75 sq. ft., was used for "clarification." The other section, using twenty Seitz K-5 filter pads providing a filter area of 13.2 sq.ft., was used for "sterilization." Both sections were manifolded so they could be used in series, or filtering could be accomplished using the "sterilization" section only when raw water was relatively clear. Ferric chloride and lime were supplied for use in pre-treatment of water to be filtered. This equipment was capable of producing an excellent quality of water. Rated at 500 gph., it was found to have a normal run of from 600 to 4,000 gal. per set of pads, depending on the quality of the treated water. The complete set weighed 2,467 lb.

Berkefeld Filters

The use of water treatment and purification equipment embodying the Berkefeld-type filter element was not as widespread among the German ground forces as it was among the air forces. One type of unit (Fig. 2) consisted of a filter press containing Berkefeld-type elements in three frames, a hand-operated oscillating-type pump and a 75-gal. aluminum filtered water storage tank with electric heating element, all mounted on a two-wheel trailer and provided with a rock-wool-insulated sheet-steel housing. The three frames of filter elements, connected in parallel, provide a total filter area of 5.25 sq.ft. The unit was capable of pumping and filtering about 5 gpm. from relatively clear raw water.

Fig. 2. German Trailer-Mounted Berkefeld-Type Filter on Tank Trailer

The unit examined by the Engineer Board had been issued to a "flak" regiment which obviously had the 220-v. power for heating the tank contents when required. The complete unit weighed 910 lb.

A portable water purification set designated "F-4" and manufactured by Berkefeld at Celle was examined and tested. This unit consisted primarily of a vitreous enamel-lined cast-iron filter shell in which were mounted nine Berkefeld elements providing a total filter area of 3.1 sq.ft. A hand-type oscillating pump, air bell, pressure gage, collapsible steel stand, suction hose and strainer completed the unit. For transportation, the equipment was packed in a wood chest which also contained spare gaskets and some calcium hypochlorite. Tests indicate a capacity of approximately 1 gpm. from raw waters having less than 15 ppm. turbidity with a maximum run of 60 gal. The weight of the unit set up for operation was 161 lb. The basis of its issue was not definitely established.

Another self-contained water purification unit manufactured by Katadyn in Berlin for Berkefeld was generally issued to armored or airborne units. One or two small Berkefeld elements were utilized, although the later model, fabricated in 1944, had two elements in parallel, mounted in a pressure chamber. A piston-type hand-operated force pump, suction hose, spare element, chemicals and scrubbing brush completed the unit. The pressure chamber was built into a rectangular sheet-steel carrying case with a hinged top which, when closed, covered the elements and pump handle. Chemicals and scrubbing brush were carried in compartments provided in the hinged top. In the base and accessible through a small hinged door were carried the

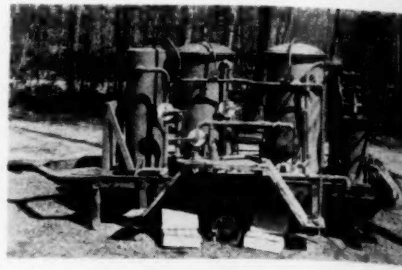

FIG. 3. German Pressure-Type Sand Filter of French Manufacture

suction hose, strainer and float. Chemicals provided included "Fallungsmittel," a powdered filter alum; "Aktivstoff," a powerful oxidizing agent with which the elements were periodically sterilized and "Oligodyn," a metallic salt for use in maintaining the "fresh taste" of the filtered water. The two elements provided a total filter area of 0.76 sq.ft. and in tests the unit produced an average of 0.6 gpm. from relatively clear water. The filtrate produced had a turbidity of less than 0.1 ppm. with marked bacterial reduction. The complete set weighed 36 lb.

All German water purification units employing Berkefeld elements could be cleaned only by dismantling or otherwise removing the elements and then scrubbing with a fiber hand brush. No mechanical cleaning or scrubbing devices had been developed.

Several types of pressure sand filters were captured and examined. These were all extremely heavy for their capacity, and none of them involved improved methods of design or operation. Pretreatment and sterilization using ferric chloride, lime and calcium hypochlorite was standard, with one type including a final filtering through activated carbon. Available evidence indicates that these units were to some extent a carry-over of earlier equipment and also that subsequent losses

on the Russian front forced utilizing equipment produced by and from designs of manufacturers in the conquered countries (Fig. 3).

Prior to Dunkerque, the Germans apparently had not used loose diatomite in connection with water filtration. After the capture of British Meta units at Dunkerque, the Berkefeld Company developed a trailer-mounted diatomite unit utilizing elements of the Stellar type. Meta-type elements were used in an alternate model. Berkefeld subsequently used a porous plastic element of "Flexalite" which was satisfactory but in time clogged to such an extent that replacement was necessary. Filters were generally furnished in pairs, so manifolded that they could be operated either in parallel or in series; the latter method was preferred for producing safer water. Backwashing was accomplished using filtered water, at a rate equal to the filter rate. Diatomaceous silica used with this equipment was blended with activated carbon and other chemicals to form "gels" within the filter cake. Normal filteraid precoat was slightly less than 0.1 lb. for each square foot of filter area, and 600 to 1,200 gal. were produced per pound of filteraid.

Chemical Warfare Countermeasures

Much development work was carried out by Berkefeld, Lurgi and Seitz on water supply equipment for use in treating waters containing toxic chemical warfare agents. All involved the use of activated carbons, in either powdered or granular form. German carbons used in treatment had surface areas of from 300 to 1,000 sq.m. per g. as determined by methylene blue adsorption tests.

The Seitz organization developed a filter containing elements consisting of a number of porous discs of an abrasive ceramic material. Developed primarily for use in treating raw water containing toxic chemical agents, the filter cake was formed from a mixture of powdered activated carbon, prepared cotton fiber and asbestos. By means of fixed knives the filter cake deposited on the discs was partially scraped off as the discs were rotated. Like many others developed, this unit never reached production.

The Lurgi organization at Frankfurt developed equipment for using activated carbon in de-chlorination. To super-chlorinated water was added 500 ppm. of a powdered activated carbon-filteraid mixture which was then recirculated through a filter having a wire cloth element until the effluent was clear. The wire cloth had openings from 0.2 to 0.3 mm. Using prechlorination dosages of 10 to 15 ppm., the filtered water is reported to have retained a residual of 0.02–0.03 ppm. of chlorine. For poisoned waters, 3,200 ppm. of the mixture was used.

As previously stated, the supply of water in the German Army was a troop function. Purification equipment available was generally inadequate to meet even basic requirements, so the greater portion of water needs was usually prepared by boiling before use. The general practice was to make tea or coffee for canteen filling so the troops would not notice the presence of any objectionable odors, taste or turbidity. This procedure apparently worked well in Europe where ample existing supplies from wells and municipal systems were available and could be used with reasonable safety.

Chlorination of German water supplies was not generally resorted to after early tests indicated that the troops would refuse to drink it. The

Luftwaffe in some instances practiced super-chlorination and de-chlorination but major reliance was placed on the Seitz and Berkefeld type filters to produce a virtually sterile water.

German field water quality standards were comparable to civilian standards. These included the provision that the water be completely devoid of coliform organisms and virtually free of all bacteria. Clarity was to be such that a "newspaper text may be read in indirect daylight through a depth of 100 cm. of water." Actually these standards were seldom met in field treatment. Battalion medical officers were responsible for passing on water quality with limited help from hygienists and analysts working at Army and Group levels.

German Water Supply Equipment

Field kitchens were the only water points in general use by the German armed forces. Kitchen trucks either obtained the water locally and boiled it, or, on occasions, secured filtered water from the divisional water points. For emergency distribution, 700-l. trailer- or truck-mounted tanks developed for use by field bakeries were used. No evidence was uncovered indicating the use of 5-gal. or similar capacity cans for field water supply distribution.

Pumps used by the Germans were mostly centrifugal, powered by two-cycle gasoline engines. Hand pumps, generally provided with each powered pump, had a dual purpose—to aid in priming and to supplant power pumps when lack of fuel or mechanical failure left them inoperative. All two-cycle engines were of excellent design and construction and rendered good service.

Hose was generally fitted with quick-operating-type couplings or a variation of the lug-type threaded coupling commonly used with U.S. equipment.

Deep well pumping equipment used by the Germans was limited to standard commercial types. These included several makes of deep well plunger-type pumps and a submersible ten-stage centrifugal pump powered by a 7-hp. electric motor. Suspended in the well by means of a 2-in. column pipe, the submersible centrifugal pump had capacities ranging from 42 gpm. at a setting 100 ft. deep to 15 gpm. at a setting 500 ft. deep. Over-all dimensions limited its application to wells of 8 in. or more in diameter.

German "Pioneer" or engineer organizations were supplied with small drive-point well sets of the hand-ram type. Commercial models of both rotary and percussion deep well drilling equipment were also utilized, but not extensively. It was the policy to use any and all existing wells as required, without resorting to additional drilling operations. Extensive ground water development on the continent, both in deep and shallow wells, made this policy possible.

In the field of sea water distillation equipment, the Siemens-Stott organization in Berlin had developed a double-effect oil-fired distillation unit rated at 80 gph. with economy ratio of 30 gal. of water produced per pound of fuel used. Two units of this type, manufactured in Switzerland, and evaluated by the Engineer Board, produced 102 gph. at an economy ratio of only 22.65 to 1 during test. These is no evidence of extensive use of this or any other type of distillation equipment during the North Africa Operations by either the Germans or the Italians. One fairly large thermal compression distillation unit was found at Tobruk. This stationary Naval-type unit was rated a

1,720 gph. and had been manufactured by Siemens at Milan where much of the development and experimental work was carried out.

Japanese Army Water Supplies

Information on Japanese equipment so far has been limited to brief intelligence reports and the examination and testing of representative samples of the various types which have been captured and shipped to the Engineer Board. Since October 1945, Maj. Hayse H. Black of the Engineer Board, serving with an intelligence team, has been in the Pacific Theater making a thorough study of Japanese equipment, organization and methods. Until his report is available, no broad general statement of Japanese policies and procedures covering field military water supply treatment, purification and distribution, can be presented.

From verbal reports, it appears that much of the fresh water required by Japanese troops in the Pacific area, especially those manning the island outposts, was obtained by catchment of rain water. No reports have been received indicating the use of sea water distillation equipment when no fresh surface or ground water was available.

Japanese Equipment

In the field treatment and purification of fresh water, most of the equipment used by the Japanese employed Berkefeld-type filter elements. These were of Japanese manufacture and exceptionally well designed and fabricated.

A large field water purification unit, designated "Sanitary Filtering Machine No. 1," used by the Japanese and tested by the Engineer Board, consisted of six large filter assemblies, each containing six Berkefeld-type elements; a centrifugal raw water pump powered by take-off from the truck engine; a rectangular wood 300-gal. filtered water storage tank and the necessary interconnecting valves and piping—all mounted on a truck chasis and enclosed in a sheet-steel body. The six filter assemblies were divided into banks of three on each side of the truck and were connected in parallel to the raw water pump. Six elements in each filter having a filter area of 4.89 sq.ft. provided a total filter area of 29.34 sq. ft. for the entire unit. Within each filter assembly, a series of six longitudinal brushes were provided which could be adjusted so as to maintain contact with the filter element surfaces. By means of a gear train and a series of sprockets and roller chain, the elements were rotated against the brushes for cleaning purposes. This arrangement permitted alternate cleaning of either bank of three filters. After scrubbing, the filter shells were flushed out to remove the sludge. The extremely fine pore size of the elements required a normal operating pressure of almost 50 psi. The filtered water storage tank was lined with a bitumastic paint. On the bottom of the tank was a 3-in. layer of hollow fluted ceramic cylinders that appeared to contain a small amount of silver.

Operating instructions for this truck-mounted unit contained no reference to pretreatment of raw water before filtering. Periodic sterilization of the unit was accomplished by recirculating a 3 per cent carbolic acid solution through the unit for about 3 minutes, followed by flushing with filtered water to remove the odor. In testing this unit with raw water containing 65 ppm. turbidity, the filter rate varied from 5 to 10 gpm. With water pretreated to a turbidity of 1.0 ppm., the filter rate was from 10 to 15 gpm. and the average

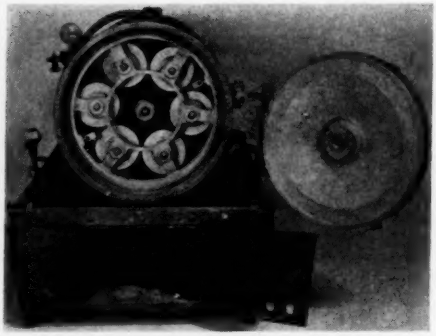

FIG. 4. Filter Section, Japanese Berkefeld-Type Portable Filter

length of the run was 30 minutes. The effluent, approaching 0-ppm. turbidity, indicated nearly complete removal of all suspended and organic matter. The weight of the unit without tools and spare parts was 10,100 lb.

Another smaller Japanese filter, designated "Water Purifier 'C'," was examined and tested. This portable unit weighing 190 lb. complete consisted primarily of a filter section and a pumping and accessory section. The filter section consisted of a pressure filter shell mounted on a pan-type sheet-steel base and provided with a sheet-metal cover, which, when set up for operation, served as the filtered water reservoir (Fig. 4). The filter contained six Berkefeld-type elements providing a total filter area of almost 5 sq. ft., and was provided with flushing valve, pressure gage and vent cock. In the head of the filter shell was a gear train which, by means of a small hand crank, provided for the scrubbing of the elements by rotating them against a centrally located fiber and brass wire brush. The pumping section (Fig. 5) consisted of a metal-bound plywood chest with hinged cover in which were mounted two hand-operated oscillating-type force pumps, a rack for a complete set of spare filter elements, spare scrubbing brush and gaskets, pump handle, and the necessary interconnecting suction and discharge hose. During tests with raw water having turbidities ranging from 550 to 25 ppm. and at a pressure of 40 psi., the unit produced from 2 to 20 gal. per run at rates from 1.9 to 3.0 gpm. The effluent was uniformly excellent, having turbidities of less than 0.1 ppm. This unit incorporated no pre-treatment of raw water in its operation. The basis of its issue was one per company.

Small Japanese Units

A single element, "Ishii Squad Type" filtering unit, consisted of a filter shell, single-acting piston-type hand pump with detachable mounting pedestal, connecting hose and scrubbing crank carried in a small steel chest, the cover of which was used as the filtered water reservoir. The single Berkefeld-type element was located eccentrically

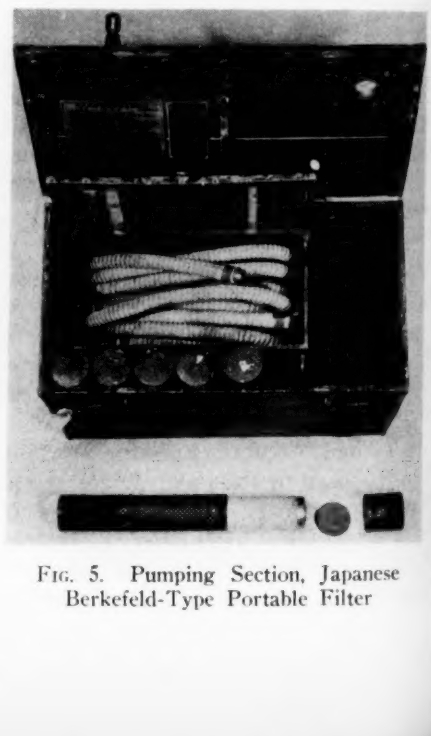

FIG. 5. Pumping Section, Japanese Berkefeld-Type Portable Filter

within the filter shell and in contact with a fine flat brass wire brush. Cleaning of the element was accomplished by rotating the element against the brush, followed by flushing. In operation this unit, which has a filter area of 0.82 sq.ft., produced an average of 0.25 gpm., with a normal run of less than 1 gal., from waters having turbidities of less than 25 ppm. The complete unit weighed 23 lb.

A small "Ishii Individual Type" water purification unit was also tested. This unit weighed $4\frac{3}{4}$ lb. and consisted of a small pressure cylinder and integral single-acting force pump, detachable foot piece, suction hose, canvas carrying case, and a small metal case containing four bottles of chemicals. A small Berkefeld-type filter element was located eccentrically within the filter shell and in contact with a fine brass wire brush. The element provided a total filter area of 0.16 sq. ft. Cleaning was accomplished by turning the small discharge spout which rotated the element against the scrubbing brush, followed by flushing. From raw waters having turbidities of less than 50 ppm., this unit produced an average of 0.5 gal. of filtered water per run at a rate of approximately 0.25 gpm.

The small "Ishii Individual Type" was the only Japanese unit examined which included chemicals for pre-treatment and sterilization. One of the small bottles with this unit had contained potassium aluminum sulfate and another labeled "Hodagoya Liquid" contained sodium hypochlorite. The other bottles were empty and unlabeled.

Two other Japanese filters employing Berkefeld-type elements and obviously designed for use by small field medical detachments were examined. Manufactured by Shofu, neither of these units incorporated mechanical scrubbing devices for cleaning the clogged elements.

One Japanese siphon-operated, filter-cloth-type purification unit was tested by the Engineer Board. The filter consisted of a heavy brass wire helix 4 in. in diameter, capped by brass cylindrical shells, one of which was fitted with an outlet elbow, a 6-ft. length of $\frac{3}{4}$-in. hose and one piece of filter cloth 9.6 ft. long, 2.7 ft. wide and $\frac{3}{64}$ in. thick. The unit included two 9.5-lb. cans of powdered potassium aluminum sulfate. It is not known whether chemicals for sterilization of filter cloth were included in the set. A test made with two wraps of the filter cloth around the helix and with a coagulant dose of approximately 300 ppm. to a raw water having a turbidity of 120 ppm. indicated a normal filter rate of approximately 1.1 gpm. with a total run of 32 gal. The effluent had a turbidity of 2.5 ppm. With untreated raw water of the same initial turbidity and 1-ft. differential head, only a moderate reduction in turbidity was accomplished. The possibility of contamination of the filtered water by seepage of raw water through the edges of the filter cloth was obvious. Great care would be required in wrapping the cloth on the helix, and in washing and sterilizing the cloth between runs, to assure a reasonably safe effluent.

One small individual filtering device was received which consisted primarily of a plastic strainer receptacle in which apparently a treated cotton plug was inserted, and a small rubber tube about 30 in. long attached to one end. Apparently the operator immersed the filter in the water and sucked on the tube. No tests were run on this unit pending receipt of further information and sample filter cotton plugs.

No gasoline or diesel engine-powered general purpose Japanese pumps have

been received to date by the Engineer Board. With field equipment generally limited to small capacities, all pumping was accomplished by means of rotary- and oscillating-type hand pumps. Several hand-operated pumps, of the oscillating-vane type, were examined. These were carefully made of aluminum and brass.

One Japanese deep well plunger-type pump was examined. This unit was powered by a small, one-cylinder, two-stroke cycle engine. The pump head proper was of the pitman drive type with a non-adjustable 16-in. stroke. The complete assembly, involving a standard commercial heavy-duty pump head and a lightweight engine, was too cumbersome for normal military field use and underpowered if subjected to long periods of continuous service.

Acknowledgments

As previously indicated, much of the information contained herein has been taken from evaluation reports prepared by the Technical Staff of the Engineer Board Water Supply Equipment Branch and from the report of Lt. H. E. Hudson Jr. covering his part of the investigation in Germany, all of which have been transmitted to the Chief of Engineers, U.S. Army.

Summary

In general, the quality of water produced by both German and Japanese purification equipment was excellent. The use of chemicals for sterilization of filtered water was exceptional rather than a general policy, leaving considerable doubt as to the ultimate safety of the water when consumed, subject as it would be to after-contamination in handling. The weight of equipment and expendable supplies required to produce water using the enemy equipment examined was high in comparison to unit capacities. Quantities of water supplied enemy troops were obviously meager in comparison with minimum American requirements.

Co-operative Sanitation in the Americas

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THE Americas are undergoing a "sanitary awakening." This awakening started first in the United States and is spreading throughout the hemisphere. The momentum of sanitation progress undoubtedly will continue to increase in the future, producing far-reaching economic results and raising the standards of health and living for all peoples of the hemisphere, as well as affecting world standards. It is well known that health and sanitation are very important factors in economic development and economic progress. Peoples who are debilitated by malaria, malnutrition or intestinal or other diseases cannot work sufficiently to produce—and, in turn, consume—what is necessary to maintain the minimum economic standards so important to world trade and commerce.

In supplementing the "sanitary awakening" in the Americas, eighteen countries and the United States have been working together through co-operative agreements in the fields of health and sanitation. These co-operative programs were designed to help meet, and to demonstrate the solution to, such major needs as water supply; excreta disposal; general sanitation; malaria control; preventive, therapeutic and health education services; and the training of health personnel. These are part of the over-all program for: (1) developing the economic and human resources of the hemisphere; (2) controlling anti-American activities and developing better understanding between the peoples of the hemisphere; and (3) promoting hemisphere defense.

The Inter-American Co-operative Health Service Program was first undertaken as a war measure formulated by the conference of foreign ministers at Rio de Janeiro in January 1942, when the far eastern sources of rubber, tin, cinchona, manila hemp, vegetable oils and other vital materials had been lost.

The foreign ministers of the American Republics recognized the importance of health problems when they agreed that "adequate health and sanitary measures constitute an essential contribution in safeguarding the defensive powers and the ability to resist aggression of the peoples of the American Republics."

A safe environment is the fundamental foundation for the protection of health. In countries where malaria is a leading cause of death and debilitation, where in many areas 98 to 100 per cent of the population suffer from intestinal parasites, where amebic dysentery is frequently a major cause of illness, where reported annual typhoid fever death rates in 1942 reached above 30 per 100,000 population, and where reported infant mortality rates usually exceed 100 per 1,000 live births (largely due to enteric diseases), physical, men-

tal, and economic efficiency cannot be attained without widespread and persistent application of all known measures for improvement of the sanitation of the environment. The problems of sanitation are more difficult and require greater vigilance in tropical areas; however, it has been shown that it is entirely possible to lead a long and productive life in tropical areas by observing hygienic precautions that have as basic premises a safe water supply, suitable disposal of human wastes and control of insect-borne diseases.

The question might be raised: Why has basic sanitation lagged in many areas of the world? The author's answer is that poor sanitation is tied to the vicious circle of economic development; that is, because of poor sanitation and health conditions, many peoples have not been able to develop economically so they could pay for good sanitation. Another very important factor is the absence of a sanitary or public health engineering profession in these areas. It seems to be a common observation in all parts of the world that where the sanitary engineering profession has not developed, environmental sanitation has been lacking in spite of other activities in the field of public health and medicine. In many parts of the world it is not uncommon to find reasonably good medical service and hospital care but poor environmental sanitation; hospitals are filled with cases which good water supply and excreta disposal systems could have prevented.

Sanitary engineering is a progressive young branch of the engineering profession in Latin America, but it is hampered by the great shortage of engineers. Because of the industrial and building development in these countries, a premium is placed on engineering, and it is difficult to attract engineers into the public work of sanitation.

Water Supply and Purification

Latin America has many fine water supplies, which comparable North American cities would be proud to own. The development of safe water supplies, however, is still the most critical sanitary problem confronting the South and Central Americas. As yet, standards of quality such as those of the United States Public Health Service have not been widely developed or used. Many relatively large cities do not have a safe water supply, and many of the smaller cities have not been able to develop a public water supply at all. The boiling of water is the accepted precaution used by people who are familiar with the hazards of contamination.

In general, water treatment is practiced only in the large cities. Slow sand filters until recently have been used more commonly than the rapid type because of the high cost of chemical coagulant and the need for simplicity of operation. Rapid sand filtration is now being widely adopted. North American water plant design practice is now more common, although in the past European practice and European equipment were used more extensively. Because of the shortage of chlorine, chlorination equipment and shipping facilities, only large cities are able to chlorinate their water supplies. The maintenance of a desirable residual throughout the distribution system is uncommon or unknown.

The pipe sizes in distribution systems are generally smaller than those used to serve cities with similar populations in North America. One reason for this is that fire protection is less important because buildings are often

unheated in the warmer climate. Also, less fire protection is needed for the better class buildings, which are constructed of concrete, brick and tile, and the poorer quality buildings can be replaced more cheaply than fire protection could be provided.

The distribution system pressures are lower than is common in North America. Low pressures and insufficient maintenance of the systems are often responsible for contamination of water which may have been safe before entering the system. Because the demand for water often exceeds the capacity of the system, the water is often turned off during the night. Consumer pumping from the mains creates low or negative pressures and causes serious contamination of the mains. Cross-connections are a very serious hazard in many cities.

The lack of proper maintenance, because of the shortage of trained personnel, political upheavals in management and insufficient revenue to finance repairs and extensions, is also a serious problem. Only a small percentage of the service connections are metered, hence there is a great wastage of water. For example, a recent pitometer survey made in San Jose, Costa Rica, showed that 90 per cent of the unaccounted-for water was wasted in the homes, because plumbing fixtures leaked or the water was allowed to flow from the taps continuously.

Hydrologic information on stream flow and ground water is very limited. Ground water will no doubt prove to be the principal source of supply for smaller cities. Most of the American countries are developing hydrologic information and are studying ground water utilization.

The postwar period will undoubtedly witness rapid progress in water supply development. Financial problems in small cities and the inability of the customers to pay the cost of water and service connections will present difficulties. In contrast to public water supplies in North America, which usually started from small beginnings and were then expanded with earnings and short-term loans, many Latin American cities which have no public water supplies will have to finance a large initial outlay. These difficulties may be partly offset by the fact that in many countries there is centralized control of planning and financing public works.

Co-operative water supplies have been initiated in fourteen countries by the Inter-American Co-operative Health Services. These include 63 water systems, some having treatment plants, others consisting simply of well supplies and distribution systems.

Sewage and Waste Treatment

Similar to the water supply situation in Latin America, sewage and waste disposal vary from very good in some of the large centers to very poor in smaller cities and rural areas. The disposal of human wastes is probably the least developed of the sanitary arts. In medium and small cities and in rural areas, there are few facilities for waste disposal. Even privies and latrines are not common in poorer areas. As a result, the incidence of intestinal disease is high. Sanitary disposal of excrement is necessary before hookworm and the intestinal diseases can be controlled. There is a very limited value in treating people for intestinal diseases when they are immediately reinfected in an insanitary environment. As in the United States during the past few decades, much of the infant mortality in Latin America is due to the enteric diseases.

One of the major difficulties of developing sewage systems in many tropical areas is that the cost of sewers and the accompanying sanitary facilities is out of proportion to the value of the dwellings and property being served.

There are some very fine sewage treatment plants in some Latin American cities; however, extensive sewage treatment in a large part of Latin America is quite some distance in the future. Large cities are generally located on the coast or on large streams, where sewage disposal without treatment is satisfactory. The low population density and the heavy rainfall result in a large dilution factor in the streams. The rainfall is also of great sanitary value in small cities and rural areas, where there are few privies.

In the arid coastal regions of western South America, where every drop of water is valuable, sewage is discharged into irrigation ditches. Since the use of sewage for irrigation is an economic necessity, sewage treatment is receiving attention in those areas.

Design practices for sewage systems and sewage treatment in Latin America differ from those in the United States because of the climate and the quality and quantity of liquid wastes. Refuse and garbage are most commonly disposed of by land-fill. Excellent progress has been made with the use of sanitary land-fill in many places. The garbage and refuse are usually fairly dry, and the quantity per capita is much less than in the United States. While incineration is used in many places and may be used almost as satisfactorily as in the United States, it is not as economical as sanitary fill. Sanitary fill, which is a more successful method for disposing of refuse in the uniformly warm climate of most of Latin America than in more temperate climates, can be used to reclaim low lands and fill swampy areas which are focuses of mosquito breeding.

Malaria, venereal disease and tuberculosis control, hospital and health center construction and operation, medical care for workers in strategic materials areas and health education have been among the major activities of the Inter-American Co-operative Health Services. Malaria control has been effected in fifteen countries around Army and Navy bases, airports and seaports, and in rubber, sisal, quartz, and other strategic materials areas. About 70 health centers are being operated. Physicians, engineers, nurses, and other professional and technical personnel are being trained in the United States and in the other American Republics.

The program is operated in each country by the Co-operative Service which functions as a division of the National Department of Health. A small field party of professional and fiscal personnel from the United States works with national technicians in planning and directing the program. All projects are agreed upon by a representative of the National Government and the United States Chief of Field Party. The Chief of Field Party serves as director of the Co-operative Service and, as such, acts as an employee of the National Government. There are less than 200 United States employees in the 18 countries and about 12,000 local employees, including about 9,000 unskilled workmen.

At present the other American Republics are supplying more of the money than is the United States. The Institute of Inter-American Affairs, a U.S. Government corporation, carries on the co-operation for the U.S. with funds voted for the work by Congress.

Boiler Water Quality and Treatment

By Kenneth W. Brown

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Presented on Oct. 23 and 25, 1945, at the California Section Regional Meetings, Los Angeles and Berkeley, Calif.

WHILE there are a limited few who might be interested in exploring the whole field of boiler water conditioning, it seems safe to assume that the average water works operator would have little use for anything more than a brief outline of fundamental principles. At the most, all he needs is a general idea of what troubles may be expected, what effects they have in operating steam plant equipment, and what can be done to correct them.

Nature and Effect of Deficiencies in Boiler Water Quality

Most or all of the complications brought about by deficiencies in boiler water quality fall in the general categories of scale formation, corrosion, priming and foaming and caustic embrittlement. Each of these, of course, is a subject in itself and only the barest essentials can be touched upon in this discussion.

Scale Formation

In the process of producing steam by the evaporation of boiler water at an elevated temperature and pressure, the concentration of the boiler water gradually increases and certain changes take place in its physical and chemical characteristics. Oxygen and carbon dioxide are liberated by the heating process and leave the boiler along with the steam, but the mineral constituents are left behind, finally building up an accumulation which has to be relieved by periodic blowdown. Some of these constituents are highly soluble but others readily precipitate in the form of a flocculent sludge or an adherent scale. Sludges in general are relatively harmless and are removed for the most part by blowing down at regular intervals. Scale formation, however, is more difficult to handle and corrective treatment must be formulated accordingly.

Scale deposits, depending on their physical properties, are usually classified as hard or soft, although there is no exact measure either one way or another. Material consisting mainly of calcium carbonate is soft and easily removed by mechanical means, frequently by washing with water from a high-pressure nozzle. On the other hand, deposits containing large amounts of either sulfate or silica, or both, are extremely hard and dense and are difficult to remove, even by mechanical means.

All boiler scales, both hard and soft, are poor conductors of heat and therefore serve to insulate the heating surfaces with which they come in contact. As a result, flow of heat through the metal is restricted and a substantial portion of the total fuel consumption is altogether wasted. In addition, areas subject to high rates of heat absorption

may be badly damaged by blistering and burning and by distortion resulting from unequal expansion. Such a condition, if neglected or disregarded, may lead to a complete and possibly dangerous failure.

Corrosion

Corrosion in a steam boiler is essentially the same in principle as corrosion in a cold water system. The same factors are involved and the same general reactions take place, except that the speed of the reactions is accelerated with an increase in temperature and damage develops accordingly. In boilers, as in cold water lines, the primary culprit is dissolved oxygen. Oxygen unites with the protective film of hydrogen, which is liberated when iron goes into solution and thereby sets up a cyclic reaction leading to continued attack. Carbon dioxide, formed on the application of heat to water containing carbonates and bicarbonates, has little influence on boiler corrosion but may cause serious trouble in return systems and other equipment coming in contact with condensed steam. Other potential causes of boiler corrosion are acid feedwater and hydrochloric acid formed under boiler conditions in water containing magnesium chloride.

Corrosion of boiler metal manifests itself in the form of tuberculation and pitting and is obviously a definite hazard to safe operation. Pitting is a particularly troublesome effect in that it often takes place under scale or a thin layer of rust and remains unnoticed until considerable damage has been done.

Priming and Foaming

Trouble with boiler water carry-over and wet steam is brought about by priming and foaming. Of these, priming takes place under conditions of too rapid or violent boiling and leads to a projection of droplets or even slugs of water into the steam pipe. Foaming, on the other hand, occurs where conditions are such as to restrict the bursting of steam bubbles at the boiler water surface and manifests itself in the form of a foam which may range in thickness anywhere from a thin layer to a mass that fills the steam space entirely.

Innumerable theories have been advanced to explain the phenomena of priming and foaming. Much of the evidence in support thereof is contradictory and not a little confusing, but out of it all certain fundamentals have been fairly well defined, and it can be said in general that carry-over is the result of one or more of the following conditions:

1. Complex internal construction of boiler.
2. Small steam space above the water. This may be due either to the type of construction or to maintaining the boiler water at an abnormally high level.
3. Operation at high rating.
4. Sudden opening of large valves on steam lines.
5. Loosening of scale, bringing water in contact with overheated metal.
6. Presence of finely divided solids in suspension. This effect seems to depend more on the ratio of the solid material to the material in solution than it does to the actual amount of solid material.
7. Presence of saponifiable organic matter. Soluble sodium salts of organic fatty acids, even in small concentrations, are definitely capable of producing severe boiler conditions.
8. High alkalinity and high concentration of dissolved solids.

Delivery of wet steam has a disturbing and detrimental effect on many industrial processes. Among them, to mention a few, are rubber curing, food processing of certain types, and practically all operations depending on the use of vacuum pans and evaporators. Trouble of this type, unfortunately, often goes unrecognized and the grief it causes, in operation or in the quality of the finished product, is either disregarded or blamed on some entirely unrelated condition.

Caustic Embrittlement

Caustic embrittlement may be defined as the action of highly alkaline water on boiler metal, especially in areas subject to distortion or strain. This condition usually develops in riveted joints below the water line and manifests itself in the formation of peculiar cracks which follow crystalline or intergrain boundaries and ultimately cause the metal to become brittle and weak. Such cracks are said to start on the dry side of the plate, running from one rivet hole to another, and are found in metal of both good and poor quality. Moreover, neither the operating pressure nor the type of boiler construction appears to be of any significance.

It is a well-established fact that embrittlement is likely to occur in any installation where the feedwater is high in sodium carbonate and low in sulfate content, or where for other causes relatively large amounts of caustic soda are either added to or formed in the boiler. Presence of silica also appears to be essential but the effect thereof has not been clearly defined and nothing much is known beyond the fact that even a small quantity of silica has a definite bearing on the rate of attack by a caustic water.

As to the actual mechanism involved, laboratory experiments show that a concentration of about 103,000 ppm. is necessary to produce cracking. According to available evidence, such a condition develops in the seams of a drum and is brought about by extremely small cracks which allow boiler water to flash out as steam, leaving a residue of caustic soda on the dry side of the metal. When caustic thus deposited reaches a high enough concentration, it reacts with iron to form magnetic iron oxide and hydrogen, and sets up the destructive action leading to ultimate cracking of the metal.

Correction of Deficiencies in Boiler Water Quality

The correction of deficiencies in boiler water quality involves either one or both of two general methods, namely, external treatment and internal treatment. Of these, external refers to treatment of make-up water before it enters the boiler, while internal means treatment which takes effect inside the boiler. Both have their place and often they are used together.

External Treatment

External treatment methods (mainly clarification and softening) can be reviewed briefly:

Clarification. Removal of mud and other suspended material is effected by the usual processes of settling, coagulation, sedimentation and filtration. These represent common practices in the water works field and require no further attention.

Softening. Softening removes scale-forming calcium and magnesium and may be employed also for reduction of alkalinity, silica and total solids. Methods of softening ordinarily used and some of their limitations are:

1. *Lime and Lime-soda.* Most of these nowadays are of the hot process type. This is because the softening reactions are greatly accelerated by heat, temperatures near the boiling point causing almost complete precipitation of calcium and magnesium in a matter of fifteen to twenty minutes, as compared to three to four hours in the cold. As a result, the plant size for a given capacity is very much smaller than it would be for an ordinary water works installation. Furthermore, the heat required for this process usually comes from exhaust steam and is therefore saved and made to do useful work instead of being wasted.

Hot process softening, in addition to calcium and magnesium precipitation, is effective also in partial removal of silica and in reducing alkalinity to a desirably low level. Water so treated, however, carries a residual hardness, usually 20 to 40 ppm., and the process requires more than ordinary care in operating supervision and control.

2. *Sodium Zeolite.* Sodium zeolites, both natural greensand and synthetic, are widely used in the low-pressure field. Greensand, though of substantially lower exchange capacity, is the best for low silica water, while synthetic zeolite is generally safe to use if silica exceeds 25 to 30 ppm. Anything less than that might lead to gradual disintegration and ultimate failure of the synthetic material.

Sodium zeolite plants are very simple and easy to operate and require little attention aside from valve manipulation for periodic regeneration. Even this little chore is eliminated, however, in the fully automatic units, control of which involves nothing more complicated than pressing a button or two and seeing that the brine tank is kept properly filled. On the other hand, sodium zeolite is by no means a complete and self-sufficient method of treatment. Dissolved solids in water so treated increase about 5 per cent, whereas the lime-soda method causes a reduction, the treated water in most cases averaging about 20–25 per cent less than the raw water. Another objection to zeolite is that all of the calcium and magnesium bicarbonates are changed to sodium bicarbonate, which, on the application of heat, breaks down to form sodium carbonate and sodium hydroxide. In a boiler such a condition leads to high alkalinity and resulting trouble with bad boiling and wet steam. Caustic embrittlement is also a potential hazard, particularly in boilers operated at pressures that are in excess of 150 psi.

3. *Carbonaceous Zeolite.* Carbonaceous or hydrogen zeolites are exchange materials of organic origin which can be regenerated with either brine or acid. When the latter is used, they give up hydrogen instead of sodium in exchange for calcium and magnesium and produce a soft effluent containing a mixture of carbonic, hydrochloric and sulfuric acids. These acids, of course, must be properly neutralized before the water can be used for boiler feed purposes. One way is to add caustic soda or soda ash, but the preferred method is to blend the acid effluent with a separate sodium zeolite effluent, using enough of each to produce completely softened water with a suitably low alkalinity. This method, coupled with thorough removal of carbon dioxide, leads to an appreciable reduction in dissolved solids and makes it possible also to keep feedwater alkalinity at any required level. But here again there are several limitations, most of which stem from difficulties in operating control. If the danger

of acid feedwater is to be avoided, alkalinity tests have to be made at rather frequent intervals and flow rates adjusted accordingly. Adequate storage is helpful but even then there is a need for fairly close supervision of the blended water going to the boilers.

4. *Resinous Zeolite.* Use of resinous and similar exchange materials for the removal of both anions and cations and the production of water comparable in quality to distilled water is confined for the most part to process applications. This method is relatively untried in the boiler water field and possibly is too expensive for general use. In any event, silica is not removed, and further treatment would have to be provided for installations requiring water of low silica content.

Internal Treatment

All of the methods just reviewed usually have to be supplemented by internal treatment, the basic principle of which is maintenance of boiler water conditions which will assure precipitation of residual calcium in the form of a flocculent sludge instead of an adherent scale. Two compounds which form such sludges are calcium carbonate and tricalcium phosphate. If the carbonate content of boiler water is kept above a certain ratio when compared to the sulfate content, any calcium present will react with the carbonate instead of the sulfate, and sludge will be formed instead of hard scale. The required carbonate-to-sulfate ratio varies according to operating pressure and ranges from about 0.10 for 100 lb. to about 0.60 for 550 lb. Carbonate conditioning, however, is not altogether dependable, especially for pressures in excess of 150 lb. Sodium carbonate tends to hydrolyze at temperatures above 185°C., forming sodium hydroxide, or caustic soda, and liberating free carbon dioxide. When this happens, the carbonate ratio is no longer maintained and calcium may be precipitated as a hard sulfate scale.

Phosphate conditioning, because of the stability of the phosphate ion at high temperatures, gives good results at all pressures and is essential for high pressures. With this method, residual calcium goes down as tricalcium phosphate instead of calcium sulfate and forms a flocculent sludge which can be readily removed by blowdown. The amount of phosphate required depends on the calcium content of the feedwater, the amount of sulfate in the boiler water and the operating pressure. Enough must be used to produce free or excess phosphate, the usual range being 30 to 50 ppm., with a maximum of 100 ppm. It is necessary also to maintain a caustic alkalinity, expressed as hydroxyl or OH ion, ranging from 60 to 120 ppm. and preferably at or close to 100 ppm. This assures precipitation of calcium as tricalcium phosphate and brings about maximum removal of calcium for a given amount of phosphate.

The type of phosphate to use depends on the alkalinity of the boiler water. For low alkalinity water and water requiring added alkali in the form of soda ash or caustic soda, the cheapest source of phosphate ion is trisodium phosphate. For medium alkalinities, represented, for example, by unsoftened San Fransicso water, the preferred source is disodium phosphate, either anhydrous or crystalline. For high alkalinities, as represented by many of the well supplies in the San Joaquin and Sacramento valleys, it is necessary to use the most acid material, which is monosodium phosphate. A proprietary phosphate, having the chemical name of sodium hexameta-

phosphate, is also widely used for internal treatment. This material is acid in character, being equal to monosodium phosphate in alkali-reducing capacity, and has other characteristics which are said to be of value in the treatment of boiler water and boiler feedwater.

Internal treatment or conditioning of still another type involves the use of colloidal materials of organic origin. These materials possess qualities of adsorption and coagulation which have very definite effects with respect to sludge and scale formation. It has been shown, for example, that tannin affects the formation of calcium sulfate crystals, causing them to be smaller and less regular than they would be otherwise. Coagulation, on the other hand, involves a condition of mutual precipitation whereby scale forming and colloid particles unite to form a harmless non-adherent sludge. Materials of this type are said to be helpful also in reducing trouble with carry-over and wet steam.

Only a relatively few colloids are suitable for use in a boiler. Potato peelings were perhaps the first to be used and apparently were of some value as a scale preventative. Tannins, notably chestnut and quebracho, are widely used at present and the Navy depends on cornstarch in combination with soda ash and disodium phosphate. Products made from seaweed are also used to some extent. Required doses vary somewhat, depending on local conditions, and usually have to be worked out by trial and error. If tannin is used, the amount present in boiler water might have to be anywhere from 50 to 135 ppm. and in any case should be high enough to produce a color approximating that of moderately strong tea.

No review of internal treatment methods can be completed without at least a brief reference to the so-called boiler compounds, many of which are useless if not actually harmful. Sold under all kinds of names and with claims frequently approaching the fantastic, they contain all too often a large proportion of water or inert material, or both and are of little or no value in keeping boiler water in a satisfactory condition. A few concerns, however, formulate compounds with reasonable care and provide in addition a service arrangement which usually involves periodic visits by an engineer or salesman, together with a laboratory check on the condition of the treated water. But even the best of the compounds are relatively expensive. If they contain soda ash or one of the phosphates, the price per pound of usable material is a lot higher than the price of similar material purchased on the open market. In any event, no one compound is good for all types of waters and all types of operating conditions and no material should be used unless its composition has been accurately determined.

Optimum Boiler Water Conditions

It might be helpful by way of conclusion to outline optimum conditions with respect to scale and corrosion control, satisfactory boiling and the prevention of caustic embrittlement.

Alkalinity

The A.S.M.E. "Suggested Rules for the Care of Power Boilers" recommend that, to avoid corrosion, the concentrations of free sodium hydroxide and sodium carbonate be kept in excess of 255 ppm. in terms of sodium carbonate, or about 240 ppm. in terms of calcium carbonate. In other words this represents the minimum phenol-

phthalein alkalinity considered necessary for protection against corrosion. No top limit is suggested because a great deal depends on local conditions, such as operating pressure, steam quality and sulfate concentration. In general, however, it is prudent to stay somewhere between 250 and 500 ppm. and to regard 750 ppm. as a top limit. Caustic or hydroxyl alkalinity, expressed in terms of calcium carbonate, should usually be not less than 175 nor more than 350 ppm. Operation in this range assures effective precipitation of calcium and magnesium—calcium as phosphate and magnesium as hydrate —and serves also to limit the danger of boiler metal cracking by caustic embrittlement.

Dissolved Oxygen

This requirement applies to feedwater. For pressures up to 350 lb., the safe limit with respect to possible corrosion is about 0.25 ml. per liter, or 0.18 ppm. For pressures over 350 lb., the limit is generally set at 0.02 ml. per liter.

Hardness

Boiler water hardness should be zero at all pressures.

Sulfate-to-Carbonate Ratio

For protection against boiler metal cracking by caustic embrittlement, the A.S.M.E. Suggested Rules call for maintenance of the following ratios:

Operating Pressure Gage, lb.	*Sodium Sulfate-to-Sodium Carbonate Ratio*
0 to 150	1 to 1
150 to 250	2 to 1
Over 250	3 to 1

In the above, sodium carbonate represents sodium hydroxide and carbonate alkalinity expressed in terms of equivalent sodium carbonate.

Total Solids

Total solids limits established by the American Boiler Manufacturers' Association range from 1,000 to 3,500 ppm. and depend on operating pressure. Up to 300 lb., the limit is 3,500 ppm., while 1,000 ppm. is for pressures between 1,000 and 1,500 lb. Actually, and especially in the low pressure range, much depends on the type of boiler and the rate at which it is operated in comparison to its designed capacity. In the case of fire-tube boilers, for example, 5,000 ppm. is a conservative limit for normal rating, and higher concentrations are by no means uncommon.

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Bacterial Oxidation of Ammonia in Circulating Water

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A contribution to the Journal

GREAT volumes of cooling water are used by the Standard Oil Company of New Jersey at Baton Rouge, 42,000 gpm. being circulated through the usual industrial heat exchangers, condensers, etc., in the Butyl Rubber project alone. Laboratory analyses are obtained on a routine basis primarily to correlate plant cooling equipment performance with circulating water composition. On several occasions, however, the water analyses have served as a direct tool in locating equipment failures. In May 1945, the rupture of a tube in an ammonia cooler caused a reduction in the system alkalinity. This has recurred four times since, and each time as soon as the leaks are repaired the circulating water analyses tend to return to normal. This phenomenon is caused by the action of certain bacteria, laboratory tests demonstrating their ability to bring about the conversion of ammonia to nitric acid.

The change in composition of the circulating water was noticed when the regular weekly samples were analyzed. Check samples were obtained and the first analyses confirmed. A simple explanation of the cause for the drop in pH from 8.5 to 6.3 and the decrease in alkalinity from 134 to 17 could not be found. Analytical data are given in Table 1. A sulfuric acid leak into the water system would result in abnormal sulfate content and a hydrochloric acid leak would increase the chlorides; however, the sulfates and the chlorides were absolutely normal.

Since both well water and clarified Mississippi River water are used as make-up for this cooling water system, the well water was discontinued. It was felt that anything which might contribute to the complexity of the problem should be eliminated. The use of sodium hexametaphosphate, the only chemical being added to the circulating water, was also discontinued; however, no noticeable change in water composition was effected.

In the course of testing, an ammonia nitrogen determination was made with a surprisingly high value being indicated. This was checked and a further attempt to find other forms of nitrogen disclosed that the nitrate nitrogen content of the recirculated water was about twenty to thirty times the normal value. Some oxidizing agent was evidently forming nitrates from ammonia. Several possible sources of ammonia contamination were present, but it was hard to believe that this difficult oxidation was taking place in the circulating water system.

All ammonia exchangers were checked for leaks. The cooling water leaving a group of ammonia exchang-

TABLE 1

Circulating Water Analyses

Date	pH	Alkalinity, *ppm.*	NaCl, *ppm.*	SO_4, *ppm.*	N. *ppm.*	
					NH_3	NO_3
4/22	8.5	136	20	46		
4/29	8.5	134	26	45		
5/6	7.3	70	23	45		
5/10	6.3	17	20	40		
5/14	7.2	20			44	40
5/16	7.1	17			20	50
	Ruptured ammonia tube repaired					
5/18	7.3					50
5/19	7.6					35
5/20	8.3	82				8
5/24	8.6					2.4
5/27	8.6	107				1.4

ers smelled very strongly of ammonia and showed high alkalinity and pH. Further checking of the outlet circulating water at the individual ammonia exchangers showed the water from an ammonia compressor after-cooler to be 7 per cent ammonium hydroxide solution, thus locating the ammonia leak. When this exchanger was removed from service and pressure tested from the ammonia side, one tube leaked badly. Further inspection of the cooler disclosed heavy calcium carbonate deposits downstream from the leak with voluminous slime formation on the upper partitions of the exchanger water box. The exchanger was mechanically cleaned and the ruptured tube plugged. Within a week all analyses were typical of the system. Well water was again used as make-up and the hexametaphosphate feed started.

Since no ready explanation of the "acid role" of ammonia could be found, it was decided to attempt to reproduce the unusual plant conditions in the laboratory. Two interesting points had been noticed relative to the samples of high nitrate circulating water obtained during the period of ammonia leakage: (1) there was a gradual decrease in alkalinity and pH, and (2) considerable light tan flocculent material settled out in the sample bottles. Microscopic examination indicated that this floc was principally of bacterial nature, but no attempt was made at a definite bacteriological identification; it was, however, decided to determine its effect on clarified water. The flocculent material from several samples was placed in bottles containing clarified water. Two days later, the pH had dropped slightly but the nitrates remained the same as in the initial water. In an attempt to increase nitrates and to see the effect on the alkalinity of the samples, ammonium hydroxide was added. The immediate effect was an increase in alkalinity and pH, but in three days a definite downward trend was noted in these values while the nitrates were increasing. Tests taken eight days after the ammonia addition showed a marked drop in alkalinity and pH and a ten- to twenty-fold increase in nitrates. Tests taken six days later showed no change and no appreciable free ammonia nitrogen present. Evidently the floc present in the samples had the unique ability to promote the change from ammonia nitrogen into nitrate nitrogen; had the ammonia supply been replenished this process would have undoubtedly proceeded further. Data from these tests are given in Table 2.

Gainey (1) has found wide distribution of bacteria capable of oxidizing ammonia to nitrites if conditions are aerobic; usually further oxidation to nitrates occurs as fast as the nitrites are formed. Since the plant cooling water is recirculated over a 36-cell forced draft tower, the dissolved oxygen is

TABLE 2

Floc Treatment of Clarified Water

Date	Sample	pH	Alkalinity, *ppm.*	NaCl, *ppm.*	N, *ppm.*	
					NH_3	NO_3
5/26	Clarified water	8.9	80	40	0.08	0.7
5/26	Clarified water + floc(a)	8.9				
5/28	Clarified water	8.15				0.7
5/28	Clarified water + NH_4OH					
5/29		9.3	113			
5/31		9.2				
6/1		8.7				2.2
6/5		6.85				10.2
6/11		7.0	41	40		10.0
5/28	Clarified water	8.8	80	37	0.07	0.8
5/28	Clarified water + floc(b)	8.8	75	37		0.8
5/28	Clarified water + NH_4OH					
5/29		9.4	129	37		
5/31		9.3				
6/1		9.0				2.2
6/5		6.5				16.0
6/11		6.6	28	37	0.2	16.0

(a) Floc in this test from one 5/16 sample.
(b) Floc in this test from four 5/16 samples; greater volume of floc than first test.

near saturation long enough to be available for oxidation. An average retention time of 18 hours is calculated by dividing the volume of the cooling system by the make-up addition rate of 1,000 gpm.

A drop in alkalinity has been reported when the growth of nitrifying bacteria is promoted (2). This drop in alkalinity was the first indication of plant trouble (3). Despite the difficulty in growing and isolating these bacteria in the laboratory (2), ideal conditions for their growth apparently have existed when ammonia leakage occurred in the plant.

The bacteriological change accompanying ammonia leakage in the plant with its paradoxical chemical effect has been successfully adopted as a convenient tool in locating failures in plant equipment. Now, when the circulating water pH shows a drop, a search for a leaking ammonia exchanger is immediately started; chemically speaking, a truly unusual procedure.

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Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34**: 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34**: 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

FOREIGN WATER SUPPLIES—GENERAL

Institution of Water Engineers. Presidential Address. HENRY FRANCIS CRONIN. Wtr. & Wtr. Eng. (Br.) **48**: 315 (Midsummer '45). First general meeting held on Apr. 11, 1896. Institution now has membership of 857. White Paper of '44 and Water Bill of '45 largely concerned with matters of policy. One result of Water Bill will be closer and more frequent contact between engrs. of Ministry of Health and engrs. in charge of water works. One of greatest needs in development of nation's water supply is information on location of water resources. Perennial topic is that of poln. of waters. For many water works, assessment of compensation water is of greatest importance. Postwar problem of great urgency is provision of rural water supplies. Difficulties largely financial and, to lesser extent, administrative. Necessity of detection and prevention of waste self-evident. If consumption can be reduced by 3 gpd. per head, quant. of water between 7 and 10% of supply will be made available. 100 yr. ago, Cornish engine in its heyday. Largest erected in 1857 at Southwark and Vauxhall Water Works. It had cylinder 112" in diam. and stroke of 10' and pumped 12 mgd. (Imp.) against head of 170'. Today very few Cornish engines remain. In intervening years rotative beam engines, variety of horizontal engines, and compd. and triple expansion engines have come into being. All obsolescent. Introduction of steam turbine gave impetus to use of centrifugal pump, oil engine provided alternative to steam, and now elec. motor is strong competitor to all other types of prime mover. Desirable that large proportion of young men entering water eng. profession should be graduates of univ. With object of attracting students and to encourage research, speaker would put forward plea for establishment of Chair of Water Engineering at one of larger univs. where 3-yr. course leading to special degree could be given. During war, water engrs. learned valuable lessons from bitter experience; they should not be pigeon-holed and lost. In postwar works such reasonable measures should be incorporated as would avoid repetition of practices which have been found to be source of weakness. Institution has from time to time published valuable reports, and might well establish Publications Com. Institution itself might issue publications bearing stamp of its authority. One book which would be of great use and interest to water engrs. would be Manual of British Water Works Practice, similar to publication issued by A.W.W.A. nearly 20 yr. ago. When war is over we must not expect Utopia. Demand for water will increase while water works handicapped by shortage of money. There will be arrears of maint. to overtake, obsolete plants to replace and problems of organization to straighten out.—*H. E. Babbitt.*

Water Supply in 1944. ANON. Surveyor (Br.) **104**: 5 (Jan. 5, '45). Subjects to fore in '44 include expectations that national policy would be adopted, Ministry of Water probably created, river boards inaugurated and backward organizations either merged with neighboring water authorities or otherwise dealt with. Mention made of results of expts. with ozonation, classification of water supplies with respect to hardness, measures of surge control, causes of failures of dams and of slides on earthen dams, and effects on human

teeth of fluorine in domestic water supplies. Postwar control and development of water resources much discussed. Subject of water softening advanced by presentation and discussion of data and ests. of cost involved in use of hard water. M. T. B. Whitson described model ozonation plant and results obtained from its operation. Boxley works of Maidstone's water supply described and some important schemes foreshadowed.—*H. E. Babbitt.*

Derwent Valley Water Board. ANON. Wtr. & Wtr. Eng. (Br.) **48**: 613 (Nov. '45). Board was incorporated in '99 by Derwent Valley Water Act, with representatives of Derby, Leicester, Nottingham, Sheffield and also of Derbyshire County Council. Under Act, local authorities should be entitled to receive max. of 5 mgd. (Imp.), divisible between 4 corporations. Sources of supply are upper reaches of River Derwent and its affluent, River Ashop. First installment of scheme consisted of Howden and Derwent reservoirs, aqueduct and filters. Board, in '20, obtained power to divert waters of Rivers Ashop and Alport into Derwent Res., increasing available supplies from 13,434 to 20,064 mgd. (Imp.). Third installment of works was Ladybower Res., largest artificial reservoir, formed by earth dam, in British Isles. Village of Ashopton on reservoir site was submerged. Last year powers obtained to secure further source of supply by constr. of 2 weirs across River Noe and Jaggers Clough Stream to divert their waters into Ladybower Res. Compensation water is at rate of 3.7 mgd. (Imp.).—*H. E. Babbitt.*

Water Supplies in the County of Durham. Wtr. & Wtr. Eng. (Br.) **48**: 560 (Oct. '45). (1) ALFRED B. E. BLACKBURN: In June '39 of 10,294 parishes in England 69.2% had piped water supply, and of 892 parishes in Wales 69.6% had piped supplies. County of Durham had piped supplies in 88.1% of its parishes. Since '44 Durham Co. Agric. Com. has been investigating possibilities of extending water supplies, particularly to farms. In addn. to larger statutory water works in county, there are private industries, mostly collieries, supplying water for own requirements and for domestic purposes to colliery villages. Sources of supply, in addn., can be tapped from rivers in their upper reaches. Increasing cost of supplying processed water must be met by willingness on part of consumers to use water economically. (2) J. ARTHUR RODWELL *Ibid.* p. 564: County fortunate in having within its borders sources of supply of water of excellent qual. ample to meet all needs if provision made for its storage. Care has to be taken in impounding these waters because flashy character of some of streams' water may contain considerable amt. of suspended matter and discoloration difficult to remove. To counteract this, afforestation being developed on Burnhope and other gathering grounds. Has been asserted that large areas of woodland increase rainfall. Evapn. one of principal causes of loss in catchment area. Retardation of runoff has still another and greater effect. Snow, under trees, melts more slowly and ground absorbs water to greater extent than in open country. Forest soil not subject to such changes of temp. as open ground. Water of reservoir sheltered by woodland comparatively free from violent agitation of gales which stir up mud and silt along banks. Afforestation of catchment areas has effect of (1) equalizing runoff, (2) preventing peak flows, (3) clarifying reservoir feeders and saving silting-up of reservoirs and (4) removing much org. and inorg. matter in suspension and minimizing risk of presence of pathogenic bacteria. Impossible to est. financial benefit nor can esthetic value of well-planted woodland be expressed in terms of money. Planting of hardwoods in these islands not looked upon as good commercial proposition, whereas softwoods have found general favor. Forestry comrs. empowered to make substantial grants to local authorities for afforestation. Possibly of minor importance is esthetic value created by judicious planting. By afforestation anticipated that one of major problems relating to provision of ample supply of pure water from moorland sources of county will be solved. In Durham Co. problems of collection and purif. less difficult than those of distr., primarily because of subsidence of ground due to colliery operations. County covers approx. 1015 sq.mi. of which 200 sq.mi. to west unaffected by coal mining operations, while heavy "bearing" towards east coast has hitherto done much to prevent surface damage. Const. vigilance on part of staffs essential to prevent damage. Despite comparatively low figure for domestic consumption in county, present exploited resources insufficient to meet growing demand for water. Immediate solution lies in large amt. of water collected in coal mines in center

of county, which could be treated satisfactorily for public use.—*H. E. Babbitt.*

Electrification of the Cosford Water Works of Wolverhampton Corporation. P. H. GODDARD. Wtr. & Wtr. Eng. (Br.) **48**: 462 (Aug. '45). Only in special instances has it been possible to obtain license to proceed with needed extension to existing plants. Fortunately project was in hand prior to Sept. '39 and has been completed. Cosford water works were established in 1855 and water first supplied to Wolverhampton in 1858. Original pumps comprised duplicate, rotative Cornish beam engines with capac. of 2 mgd. (Imp.). Two sources of supply—River Wolfe and underground source. In '37, decided to replace steam with electrically-driven equip., together with complete renewal of purif. and filtration plant. Electricity supplied by Wolverhampton Corp. at 6000/6600 v., 50 cycles. Each of two main pumps driven by vertical spindle, drip-proof, slip-ring motor rated at 26 hp., 960/640 rpm., with speed variation obtained by rotor resistance in starting pillar. Each well pump driven by vertical spindle, variable speed, a-c. commutator motor fitted with pilot motor-operated remote-controlled brush gear. Each of 2 force pumps is 3-stage, double-suction driven by direct-coupled, slip-ring induction motor with direct-coupled "Scherbius" regulator for speed variation. "Single-range Scherbius" control employs a-c. commutator machine. Water coagulated with lime and alum, rapidly mixed, mechanically flocculated, pptd., and filtered through Permutit gravity filters.—*H. E. Babbitt.*

Diurnal Fluctuations of Oxygen and pH in Two Small Ponds and a Stream. R. J. WHITNEY. J. Exptl. Biol. (Br.) **19**: 92 ('42). Observations made on diurnal variations in content of D.O., pH value and alky. of water in 2 ponds and in fast-flowing stream. Samples of water taken every hour during periods of 24 hr. Observations made on Grange Farm Pond, Alvechurch, Worcestershire, on June 3–4, and on June 23–24, '37; on Selly Park Pond, Birmingham, on Sept. 29–30, '37, and Apr. 11–12, '38; and on tributary of River Stour at Blakedown, Worcestershire, on Feb. 5–6, '38. Method of sampling described designed to avoid disturbance of water. Max. variations in concn. of D.O. amounted to 2 to 3 ml./l. and occurred in spring observations on Selly Park Pond and in summer observations on Grange Farm Pond. Max. concns. of D.O. occurred at, or slightly later than, onset of darkness, and min. concns. occurred shortly after dawn. There is therefore time lag in appearance of max. concn. of D.O. resulting from period of max. photosynthesis. Concn. of D.O. in Selly Park Pond in Sept. low and showed little diurnal variation; reasons for difference between diurnal variations in this pond in Apr. and Sept. not clear. Concn. of D.O. in Grange Farm Pond consistently higher on June 3–4 than on June 23–24, although samples collected in shade on earlier date and in sunlight on later date. Content of D.O. in stream high and fairly const.; scarcity of vegetation, low temp. of water and rapidity of flow acct. for this fact. In ponds variations in pH value followed variations in content of D.O. fairly closely. Variations in pH value accompanying variations in concn. of D.O. of 1 ml./l. were 0.05 in Grange Farm Pond on June 3–4, 0.36 in Selly Park Pond on Sept. 29–30, and 0.51 in Selly Park Pond on Apr. 11–12. Alky. of ponds showed little diurnal variation. Change in pH value with change in concn. of D.O. greater the less the alky. of water, because of buffering action of dissolved alky. substances. Emphasized that comparisons of conditions in different bodies of water cannot be made on basis of results obtained at any one time of day and that frequent sampling over period of 24 hr. necessary.—*W.P.R.*

Rural Water Supplies: Ideals and Practical Possibilities. W. GRANGER. Surveyor (Br.) **104**: 403 (July 20, '45). Aim is provision of piped supply into each house. Such facilities have lagged behind in rural areas because of comparatively high cost in comparison with urban dists. Mileage of such mains can be up to 1000 times mains in urban area. In frequent cases cost of mains and services to supply cottages may be greatly in excess of market value of cottages. Source of supply serious problem. Many rural areas do not have tech. staff necessary for maint. of supply. In past, where mains have been laid on roads, it has not followed that services have been laid to abutting properties. Some hold that provision of water is national problem. Is it just that scattered rural areas should be expected to execute costly water undertakings? Practical possibilities appear to be: (1) Small supply units considered on grounds of purity only most undesirable.

(2) Excess cost, both of initial installation and maint., should be subject of grant to enable supply to be given at cost not in excess of urban supplies. (3) Urban water works should be repaid by central govt. for excess cost of extending facilities to rural dists. (4) Consideration should be given to joint authorities covering widely scattered rural areas. Rural water supply is problem which is immediately followed by scheme for sewage disposal, generally at similarly disproportionate costs.—*H. E. Babbitt.*

Rural Water Supply As an Important Task. H. DORN. Gas-u. Wasser. (Ger.) **86**: 243 ('43). Water supplies of towns in Germany satisfactory but many rural areas do not possess central water supply systems. Of communities with pops. of less than 100, 101–200 and 201–300, only 1.2, 2.25 and 2.9%, resp., possess central water supply systems. Of total of about 7400 rural communities, 7000 are without central water supply systems. Rural water supplies in Bavaria and Würtemburg good. Although impossible to standardize water works completely, hydrol. conditions often sufficiently similar to allow uniform constr. of wells. Where there is abundant and well distributed supply of ground water, scattered communities best served by separate water works rather than by centralized water supply system. After war larger areas of land in Germany will require irrigation. Not as a rule practicable to combine irrigation works with water works supplying water for domestic purposes. Moreover untreated water better for irrigation because it contains substances of value to plants.—*W.P.R.*

The Causes of the Increase of Bacteria in the Distribution Systems of Central Water Supplies. H. DEUTSCHLÄNDER. Z. Hyg. Infektionskrankh. (Ger.) **122**: 639 ('40). Observations made at water works of indus. dists. in indus. region of Rhine and Westphalia have shown that water at pumping stations usually satisfactory but that in distr. systems water of inferior bact. qual. often found. Examples of bact. depreciation in water supplies quoted. In old distr. system supplying 2 remote sections of community, reason for increase in bacteria appeared to be incrusted condition of pipes, which reduced rate of flow of water and thus lessened its cleaning action on system. In author's opinion numerous dead ends contg. stagnant water acct. for increase in bacteria. In bldg. served by another water works, heating had been increased during cold period; increases in bacteria appear to have been caused by prolonged stagnation at high temp.; no increase in numbers of *Esch. coli* observed. In third case of bact. depreciation of water, impounded water chlorinated and distributed in much-branched system, where considerable quants. of org. matter deposited. Cl demand of water increased and thus disinfecting action of Cl reduced; no *Esch. coli*, ammonia or nitrites found in water supply.—*C.A.*

The Content in Salt and Mineral Matter of the Water of the Lippe and Its Suitability for Water Supply. W. HUSMANN. Gas-u. Wasser. (Ger.) **82**: 182 ('39). In '38 Lippeverband carried out survey of mineral content of water in Lippe R. between Lippborg and Wesel. As water flowed downstream there was continuous increase in avg. content of sodium chloride, which was almost 10 times as great at Wesel as at Lippborg. Avg. increases in calcium carbonate and in total hardness between these two places about 55 and 70%, resp. In stretch of river from Lippborg to Hamm temporary hardness much greater than permanent hardness. From Hamm to Lünen temporary and permanent hardness about equal. Below Lünen permanent hardness increased and temporary hardness decreased. Taking avg. flow throughout year calcd. that 2.7 kg. of sodium chloride and 2.4 kg. of calcium carbonate (as CaO) flowed past Lippborg every second; corresponding figures at Wesel 45.1 and 6.4 kg. Considerable variations in content of mineral matter in water at some places owing to intermittent dischg. of salty waste water from mines. Variations in hardness and in content of sodium chloride greater in lower than in upper sections of river. Hardness and high content of salt in water below Hamm make it unsuitable for water supply. Water above Hamm, which contained at low water from 100 to 150 mg. of sodium chloride per l., could be mixed with water contg. little salt to give water with content of 30–50 mg. of salt per l. Generally considered that water contg. more than 500 mg. of salt per l. unpalatable, but palatability affected by presence of other substances. Entry of salt water into wells near river has not occurred to any great extent. Cattle drank river water even when content of salt at max. During most of year water of Lippe unsuitable for irriga-

tion because of its high content of salt. Floodwater has not caused damage because when river in flood content of salt low. Fresh-water fish not seriously affected by salt in lower stretches of river. Fauna of river at Lippborg typical of unpold. or slightly pold. water; fauna at Lünen typical of strongly pold. water. Nature of fauna at Dorsten indicated that some self-purif. had already occurred. Water of Lippe suitable for use as cooling water or for washing coal, but not for boiler feedwater. If it is used for cooling in condensers pipes should be of material very resistant to corrosion.—*W.P.R.*

Production, Treatment and Corrosive Characteristics of Delmenhorst Water Supply. Georg Franke. Gas-u. Wasser. (Ger.) **87**: 3: 76 (Mar. '44). Raw water from wells pumped to reservoir and then to spray chamber provided with coke layer 3 m. high, through which water flows. Up to 7 g. $KMnO_4$ per cu.m. then added, water allowed to settle for 3–4 hr. and then filtered through series of 2 filters. This treatment reduces Fe content (from 7.25 to 0.05 mg./l.) and CO_2 content, but yields water contg. about 8 mg./l. of O; this water not especially corrosive while cold, but in combination with residual free CO_2 has caused rapid corrosion of feed-water heaters and boilers. In view of low corrosion of mains and services, no central degasification plant justified, but boiler operators should use degasification plant, keep condensate out of contact with air and use protective coatings where applicable.—*C.A.*

The Geological and Hydrological Structure of the Baum Mountains. H. Schneider. Gas-u. Wasser. (Ger.) **84**: 341 ('41). Geology and ground water resources of Baum Mts. in Munsterland described. Charts given showing levels of ground water, depth of wells and variations in levels in particular wells. Results of anals. of water from 100 wells given in form of table. Information given on stratum in which well situated; depth of well; total and permanent hardness; and concn. of chloride, Fe, Mn and nitrate in water.—*C.A.*

Public Water Supplies in Eastern Germany. D. Kehr. Tech. Gemeindeblatt (Ger.) **46**: 174 ('43). Water supply of eastern Germany and German-occupied Poland discussed. In this region water supplies obtained mainly from ground water drawn from uppermost layers of rock; this source becoming depleted. Rainfall over large part of this region less than 500 mm./yr.; about ⅓ of rain falls in summer. Rain, moreover, very unevenly distributed. To improve conditions from points of view of agric. and of water supply, necessary to plant trees in mountainous dists,. construct impounding reservoirs, drain moorland, dispose of sewage on land, construct sewage works in towns and construct central water supply systems in towns and rural areas. German water supply legislation introduced into annexed territories. Planning of water supply systems and disposal of sewage for communities of different sizes discussed. Advantages and disadvantages of combined and separate systems of sewage and of separate domestic and indus. water supplies discussed.—*W.P.R.*

History of Water Supply for Strassburg. G. Trossbach. Ges. Ing. (Ger.) **66**: 15: 168 ('43). Wells drilled by Romans and water carried through channels lined with split oak boards. Later brick used. Thickness of brick walls varied with depth of trench and diam. varied between 40 and 7 cm. With increase in consumption springs tapped about 20 km. west of city and carried through pipes. Pipes consisted of 2 parallel lines, hard-baked conical-shaped earthenware. Pipes 50–60 cm. long, 200 mm. avg. diam. and 25 mm. thick. 240 mm. wide end placed about 45 mm. over narrow end of next pipe and sealed with mixture of lime and hot oil. Lines were lead on low grade. In stretches of lowest grade air holes installed. Pressure reduction shafts installed at intervals. Water stored in tower with water surface about 10 m. above street level. Work completed by 8th Roman legion about 200 B.C. System could deliver 20–25 l./sec. and supply about 10,000 people. At end of 5th century water tower damaged by Franks and system fell in disuse. City reverted to wells (public and private). In middle of 12th century existence of only two public wells known. (4000–5000 pop.). Citizens had simple wooden well structures. City suffered repeatedly from epidemics, especially those of 1349 and 1380 when 30,000 pop. reduced to 18,000; similar epidemics in 1414 and 1417. In 1424 again 15,000 people died. Pressure brought, and 78 new public wells established, which increased to 129 at end of 15th century. Next two centuries characterized by war and revolution; keeping pop. in check and preventing improvement in

hygienic conditions. In 18th century pop. increased rapidly from about 27,000 to 50,000. Pumps placed on top of public wells; often very elaborate stone and marble structures. Private systems, provided running water in bathroom, kitchen and cellar. Nearly all shallow wells. Frequently, open public wells receptacles for dead animals. At beginning of 19th century city police charged with keeping streets and wells clean. In 1860 plans made by commission for central supply. Nothing happened. In 1873 local board of health prepd. report, recommending collection of water in Vosges or from deep wells in Rhine Valley. In 1877 constr. of deep wells started. First water works supplied 120,000 with 150 l. per capita. About 1 km. from river Rhine 3 wells, each 3 m. in diam. and 8–12 m. deep, producing 500 cu.m./hr. Wells connected by siphon with storage basin. In 1899–1900 system enlarged and with extensive use of water closed again in '04–'10. During '23–'29 pumps and water works modernized for pop. of 214,000 ('26). Entire distr. system is cast iron. Consumption, 34–109 l. per capita. Hardness 490 ppm.—*Willem Rudolfs*.

Some Problems of Water Supply. WIESER. Mitt. Lebensm. Hyg. (Swiss), **33**: 52 ('42); Zentr. ges. Hyg. (Ger.) **50**: 609 ('43). Many Swiss communities have in recent years begun to obtain their water supply from ground water. This type of water most satisfactory from hygienic point of view, as spring water may be pold. by bacteria during heavy rain and melting of snow. From economic point of view springs preferable supply because usually no pumping necessary. Tendency in recent years to retain springs as supply sources because in modern warfare pumping plants vulnerable to air attack. Spring water must be chlorinated. Formation of objectionable tastes in water avoidable by using chlorine (as gas) and ammonia instead of chlorine alone; this treatment requires careful control which is expensive and impracticable in small communities. Author refers to simple chlorinator designed by Hottinger and recommended by Gerhard in which 4% soln. sodium hypochlorite used. Magno process recommended for removal of iron from ground water. Because of present shortage of soap, question of central softening plants, not yet constructed in Switzerland, is of particular importance. Some spring water, such as that from chalk region of lower Alps, is hard.—*W.P.R.*

"Green" Filters at Amsterdam Water Works. Gas-u. Wasser. (Ger.) **85**: 338 ('42). V. HEUSDEN: At times effluent from slow sand filters at Leiduin bright green; color due to presence of algae *Chlamydomonas* and *Pyramidomonas*. Respiration of these algae causes anaerobic conditions to develop in filters at night; this leads to loading of filters with org. matter. During day withdrawal of carbon dioxide from water by algae causes pptn. of calcium carbonate, which blocks filters. Under certain conditions which are not understood, algae able to penetrate filters and hence color effluent. Temp. of water and intensity of light important factors in development of algae. H. BETHGE: Sudden growth of *Chlamydomonas* noted in plankton of a pond. In general, conditions most favorable for development of phytoplankton when period of sunshine longest. Some species in plankton, however, including species of *Chlamydomonas*, developed rapidly after thawing of ice. Similar development of diatom, *Asterionella formosa*, has been observed in impounding reservoir at Chemnitz. Abundance of *Chlamydomonas* in spring traced to scarcity of animals in water. V. HEUSDEN: Water flea, *Daphnia magna*, best agent for controlling these algae; it can be introduced into filters and does not cause any difficulties. Species of *Asellus*, a crustacean, has caused trouble in distr. system in Amsterdam. This organism feeds on bacteria and protozoa in deposits in pipes and when it has become established, difficult to elim. Presumably reproduces itself in distr. system. Can be controlled by using extract of pyrethrum. Expts. on use of pyrethrum in progress.—*W.P.R.*

The Istrian Aqueduct. K. HALLER. Gesundh.-Ing. (Ger.) **65**: 158 ('42). Istrian peninsula in Italy poor in water. Only 3 permanent streams and few springs. Plan to supply water to peninsula involves area of 3700 sq.km. with 280,000 inhabitants, and includes islands of Cherson and Lussino. Most springs come to surface at heights little more than 10 m. above sea level with result that only few communities can be supplied with water without pumping. Water-supply system designed on basis of demand for water of 88 l. per head per day; this allows for wastage of 10%. Aqueduct, constr. of which begun in '39, comprises 3 independent sections. Most important section that of Quieto; water from springs of San Giovanni Pinguente, which have avg. yield of 200 l./sec., flows to circular

reservoir, which has capac. of 2000 cu.m. and which is divided into 4 chambers. Spring water has avg. temp. of 12°C. and hardness of about 18° (Fr.). From reservoir water flows to treatment plant, capac. 200 l./sec., where it is treated with aluminum sulfate, filtered through rapid filters and treated with ozone. Treated water flows to reservoir and from there is pumped to distr. system. Quieto aqueduct supplies 100,000 people. Risano aqueduct conducts water from springs, yield of which varies from 20 to 300 l./sec. Supplies 32,000 people in northwestern part of peninsula. Arsa aqueduct, which serves pop. of 60,000, conducts water from 3 springs, with min. yields of 8, 9, and 30 l./sec., resp. Water from 2 small springs pure but that from larger springs requires treatment. To supply islands of Chersson and Lussino water pumped from small lake to reservoir 194 m. above sea level.—*W.P.R.*

Water Boards of Ancient Rome. E. R. YARHAM. Wtr. & Wtr. Eng. (Br.) **48**: 399 (July '45). Roman water supply system in many ways most notable bldg. constr. in history of civilization. Until few years ago std. book on subject was Lanciani's *Comentarii di Frontino intoro gli aquedotti* (1880). In '31 Thomas Ashby's *The Aqueducts of Ancient Rome* completed. To Romans, water literally "water of life." They caused deserts to bloom in Syria, Arabia and North Africa. Byzantine historian Procopius mentions care with which Justinian tried to assure adequate water supply for its cities and forts. Water engrs. did not even overlook needs of rural areas. In Rome almost every house had its pipe from main. Almost as much is known about water supply of Imperial Rome as of 20th century London because of records made by Julius Frontinus. His reports lead one to conclusion that human nature has changed little since days of Ancient Rome. Black market in water did thriving business. Bromhead believed that about 50 B.C. 198 gpd. (Imp.) per capita available. This had increased to 300 by 100 A.D. In 1823 figures for London and Paris were 3 gpd. (Imp.) per head. Under Roman Republic maint. of aqueducts given over to contractors who employed slaves. Augustus reorganized system of maint. and Imperial Water Board set up. About 226 A.D. Aqua Alexandriana built. As water flowed by gravity grade had to be accurately surveyed. No high-pressure supply. Aqueduct constructed in Wales to Roman gold mine at Carmarthenshire. Roman aqueduct nowhere better seen than at Segovia in Spain. Even more perfect architecturally is Pont du Gard over valley at Nimes. Rousseau tremendously impressed by it and wrote: "Oh, that I had been born a Roman."—*H. E. Babbitt.*

Water Supply and Geological Structure of the Bohemian Basin. H. KÖHLER. Gas-u. Wasser. (Ger.) **83**: 13 ('40). Geology and hydrology of Bohemia described. In lower Paleozoic limestone rocks, water level varies considerably and highest in spring; hardness and content of nitrates also at max. in spring. Hardness usually 20° to 25° (Ger.). Water from bituminous and clay strata of lower Paleozoic contains large amts. of sulfates; its hardness varies from 4° to 60° (Ger.). In exceptional cases hardness may be 100° (Ger.). Water from upper Paleozoic strata varies considerably in compn.; that from coal measures has hardness of from 10° to 125° (Ger.) and content of sulfate up to 100 mg./l. Most important water-bearing rock is chalk which occurs in northern half of Bohemia. Total hardness of water varies from 10° to 25° (Ger.) and permanent hardness from 1° to 4° (Ger.). Number of artesian wells and boreholes in chalk at present time about 300; of these 26 yield mineral water contg., in g./l., 1.5–5.4 dissolved solids, 1.5–3.0 free CO_2, and 1.0–3.6 $NaHCO_3$. Greater part (80%) of water supply of Prague ground water from chalk formations. Kárany water works, at junction of Iser and Elbe northeast of city, designed to treat up to 1000 l./sec. Artesian wells furnish 9% of water; naturally filtered Iser water, 22.5%; and rest nonartesian ground water. In wet year water from artesian wells about twice as hard and contains less free CO_2 than in dry year; it has to be treated for removal of Fe and acid. Nonartesian ground water radioactive. Another water works at Prague-Podol furnishes 16% of water supply of city; water taken from Moldau R. filtered through sand, treated with alum and chlorinated. Author refers to difficulties experienced in some parts of dist. where chalk much fissured so that compn. of water in it varies with rainfall, leaving regions of dry chalk. Brief acct. given of hydrology of younger geol. formations.—*C.A.*

The Present and Future of Water Supply in the Southeastern Dobrudja. D. VASSILEV. Gesundh.-Ing. (Ger.) **67**: 19 ('44). Account

of water supply of southeastern Dobrudja based on article published in *Vodosnab. i Kanaliz.* (U.S.S.R.) **6**: 5: 41 ('42). Morphologically and geologically southeastern Dobrudja very uniform. Temp. of ground water varies little. Avg. yearly rainfall during period '91 to '15 varied from 448 to 578 mm. Water supply systems very out-of-date. Rural pop. obtains water from small streams or from wells 60 to 80 m. deep, which yield only 0.4 to 0.65 l./sec. In whole region there are about 4750 wells and 230 streams. Pop. of towns obtains water wholly or partly from private wells. No drainage systems; constant danger of polg. wells and distr. systems by sewage. Yields from munic. wells inadequate. Water works of Dobrič, largest town in region, has capac. of only 400 cu.m. a day. Central water works to supply whole of southeastern Dobrudja should be built. Estd. that in '75 pop. will be about 174,000 and demand for water for pop. and livestock will amt. to about 14,800,000 l./day or 170 l./sec. In addn. 5 l./sec. will be required for fire fighting in towns and 3 l./sec. in villages. Plan for central water works includes constr. of main and local reservoirs where water can be stored during periods of low demand. Because of great depth of ground water level it will be necessary to obtain supply from Devna wells outside region or from 6 series of wells scattered throughout region and yielding 79, 98, 8–59, 10–26, 40, and 8–12 l./sec. Devna wells yield about 3500 to 4000 l./sec.; this water has temp. of 18° to 19°C. and has somewhat insipid taste which is lost when water cooled and aerated. Compn. of water from these 2 sources and particulars of 2 schemes for central water supply system, using one or other source of supply, given in tables. Proposed that part of pops. of Balčik and Kavarna should continue to be supplied from wells near these towns.—*W.P.R.*

Water Supply and Drainage of the Rumanian Capital. D. Germani. Gesundh.-Ing. (Ger.) **67**: 16 ('44). Development of water works of Bucharest since '80, present works and future plans described. Proposed to take water from Arges R. After settlement water will be pumped through open channel to suburb of Rosu. After further settlement, about ⅓ of water will be filtered through rapid sand filters, chlorinated and treated with activated carbon. Rest of water will be used to increase flow through lakes north of city or will be used as cooling water at Grozávesti power station. Used cooling water will be dischgd. to Dâmbovita R. Development of Bucharest sewage system described. Sewage dischgd. untreated to Dâmbovita, so that increase in its flow by dischg. of cooling water will be advantage.—*W.P.R.*

Moscow (Russia) Water System. Frank Barcus. Am. City. **60**: 6: 114 ('45). Water from Moscow R. treated by sedimentation and slow sand filtration. River protected from poln. for 50 mi. above intake by having no villages, pasturage or public use of bank for this distance. Daily per capita consumption 26 gal., and there are 16,000 metered outlets for pop. of 4,000,000.—*C.A.*

Water Supply in the Dry Regions of Africa. Keller. Dtsche. Wasserwirtschaft (Ger.) **37**: 217 ('42). Water supply of former German colonies in Africa considered. Presence of ground water at all times of year at such depth that it can be easily obtained deciding factor in detg. whether dist. habitable. One quarter of annual rainfall frequently falls in one day. Greater part of rainfall lost through evapn. from soil or by transpiration of plants. Character of vegetation greatly influences runoff. Ratio of amt. lost by evapn. to that forming ground water to amt. of runoff has been given for southwest Africa as 5:2:2. Existence of large lakes in mountainous inland dists. of no advantage. Important point to increase supply of ground water; methods for this discussed. In native reserves deep pumping installations not suitable and more simple appliances for raising water required. In dists. where there is no ground water and rainfall in rainy season adequate, water must be stored in cisterns. Dew of importance in moist, hot dists. and greater development of grass cover, greater condensation of water vapor. On coast, where only brackish ground water can be obtained, removal of salts from water necessary. Irrigation briefly discussed; application of artificial rain appears to be most promising method.—*C.A.*

Concerning the Mineral Waters of Oulmes, Morocco: the Bactericidal Properties of Carbon Dioxide Under Pressure. Bul. Inst. Hyg. Moroc. (Fr.) **3**: 115 ('43). There is natural mineral water at Oulmes in Morocco known under commercial name of "Lalla Haya." Source is warm water, contg. iron salts, sodium and calcium bicarbonates in soln., rich in silica and having radioactive

properties. Water appears at surface under pressure with abundant evolution of gas, of which almost 99% is carbon dioxide. Water put up for sale as non-aerated mineral water, which is allowed to stand before bottling to permit escape of dissolved gases; and aerated water, which is bottled at once. Contamn. with coliform bacteria detected in water tanks prior to bottling and in samples of non-aerated water on sale in towns, but these bacteria never obtained from bottles of aerated water. Coliform counts carried out on bottles of aerated water showed that these organisms disappeared within 15 days. Emulsion of coliform bacteria added to bottles of water; some sealed immediately, while in others gas allowed to escape before sealing. Bottles kept at 16°C. and coliform counts detd. from time to time. Seeded bacteria disappeared from aerated water after 12 days, but in non-gaseous bottles there were more than 1000 in every drop for as long as 12 days and many hundreds remained after 17 days. Authors believe self-purif. in aerated water, as shown by disappearance of coliform bacteria, caused by carbon dioxide retained in bottle under pressure. One is able to forecast that accidental poln. in aerated bottles will not survive for more than fortnight, but such conclusion should not in any way diminish vigilance of authorities in preventing contamn. at source or during bottling processes, because natural mineral water which has lost its contained gases will not benefit from this self-purif. process.—*B.H.*

Water Supply in Eritrea. H. L. Holloway. Wtr. & Wtr. Eng. (Br.) **48**: 599 (Nov. '45). Annual rainfall is about 25″. Number of adverse factors militate against extensive cultivation and underground water conservation. Most apparent of these are: (a) 70% of rainfall crowded into July, Aug. and Sept., (b) torrential nature of downpours, (c) rapid runoff, (d) extensive erosion and (e) low humidity and high incidence of drying winds. Snow non-existent and effect of dew negligible. Absorption accts. for small percentage of total rainfall. Figures indicate runoff of from 12 to 20% in more level portions of plateau. Evapn. accts. for largest percentage of rainfall. On reservoir surfaces evapn. has been measured to be 150 to 250 mm. per mo., with avg. of 175 to 200. In certain underground formations there are underground streams but these exceptional conditions. In general, wells must depend on piercing formation which permits free seepage. Level of underground water varies with time of year and pptn. in previous wet season. Conditions not such that artesian wells can exist. In Asmara dist., water lies 6–15 m. below surface in lower portions of town. About 30% of Asmara supply obtained from underground. First dam for supply to Asmara built in '11. From '14 onwards other dams built. There are 2 main purif. plants for Asmara supply. Godaif plant is slow sand filter, with rate of 2.4 cu.m. of water per day per sq.m. Water chlorinated after filtration with 0.6 ppm. of chlorine. At Valle Gnecchi water aerated and, after flocculation, passed through sedimentation basins and then undergoes rapid sand filtration. Rate of filtration is 120 cu.m. of water per day per sq.m. In '42 pop. of Asmara approx. 55,000 Europeans and 80,000 natives. Water distributed was 4.5 gpd. (Imp.) to white people and 1 gpd. to natives. Pipe mains distributed 60% and tank trucks 40%. Water turned on mains for few hours every second day. Asmara now receiving three times as much water as in '42. In Massawa dist. rainfall low and uncertain and drainage from Altopiano must be depended on for water supplies. First water supply scheme, dating from '88, designed to draw water from bed of Mancullo torrent, 6 km. from town. New service initiated in '35 at Dogali. Plant drew on underground flow of Tamarisco stream by means of well sunk in middle of bed with sunken pumping chamber in connection. Tamarisco, like most Eritrean streams, has no surface flow except for short periods after rains. Not felt that well could be depended on for full amt. of 1300 cu.m. daily in dry year, and undersurface dam constructed in '39 to impound underflow. Plan designed to provide daily consumption of 2900 cu.m. Main dam at Damas repaired, subsidiary dam rebuilt, and secondary dam replaced with stone structure. Water supply service in practically every settlement center of Eritrea has benefited by British occupation. Agriculture could be greatly helped by long-term water conservation policy.—*H. E. Babbitt.*

Durban (S. Afr.) Water Supply. Anon. Wtr. & Wtr. Eng. (Br.) **48**: 189 (Apr. '45). Water engr. rpt. for yr. ended July 31, '43, states that activities covered: maint. of distr. system, constr. work on Umgeni water scheme at Table Mt. and Durban Heights and completion of 2-mil.gal. (Imp.) reservoir at Stella. Avg. daily pumpage 15.9 mil.gal. (Imp.). Water supply to shipping has shown tre-

mendous increase. Main extensions and connections comprised 33,848 yd. of new mains. Owing to unseasonal floods little work could be done on flood diversion control gate structure of Umgeni scheme. About 3000′ of 48″ concrete pipe aqueduct laid. Detailed exploration of river bed rock for main dam revealed serious fissure extending over half of site. Contract for main dam constr. let. Survey for aqueduct completed and line decided upon involving 22 tunnels, 3 crossings of Umgeni R., 5 mi. of 48″ concrete pipe, and remainder of 42″ and 36″ diam. steel. Contract let for addnl. pumps at Durban Heights. New chem. mixing house at Vernon Hooper dam of Shongweni scheme completed. Total quant. of water treated 4281 mil.gal. (Imp.). Total quant. of water passed through Northdene filters 2269.8 mil.gal. (Imp.). Daily avg. of 6.427 mil.gal. handled at Camperdown works of Umlaas system. Coedmore filters filtered 1687 mil.gal. (Imp.). Cost per 1000 gal. (Imp.) was 16.229*d.*—*H. E. Babbitt.*

The Sanitation of Rio Quarto [Argentina]. A. H. Montbrun. Bol. Obras Sanit. Nacion (Arg.) **6**: 31: 2 ('40). Water supply and sewerage systems of Rio Quarto, Arg., described. Water works, which comprise semi-subterranean storage tank, elevated distr. tank and chlorination equip., supply water, sufficient for pop. of 100,000 at rate of 300 l. per capita daily. Water, which is obtained from infiltration gallery on banks of Quarto R., chlorinated after filtration through permeable subsoil of river; it contains few aerobic organisms and no *Esch. coli.* Chlorine added, at rate of 0.15 mg./l., to water in distr. tank. During '38, actual daily consumption of water was 230 l. per capita for pop. of 23,000. Sewage treatment plant comprises iron screen, 2 septic tanks and 4 percolating filters; period of retention in septic tanks greater than 24 hr. Avg. daily vol. of sewage is 2000 cu.m. Effluent from plant dischgd. into Quarto R. below city, since high rainfall of region makes disposal by irrigation impracticable. Plan for separate drainage system for disposal of storm water recently put forward. Costs of water works and sewage treatment plant discussed.—*W.P.R.*

The Brisbane Water Supply. Anon. Wtr. & Wtr. Eng. (Br.) **48**: 512 (Sept. '45). Principal source of supply is Brisbane R., augmented by Lake Manchester and Somerset Reservoirs, and balance from Enoggera Res. 7783.4 mil.gal. (Imp.) of water delivered to consumers during year '43–'44. Length of trunk and retriculation mains was 1260 mi. 3 chains. More than 9 mi. of pipes were cement-lined in place during year. Approx. 1800 tons of coagulation sludge removed from low-level coagulation and sedimentation works. Avg. turbidity of raw water coagulated was 190 ppm. Three filters resanded during year. Total quant. of water delivered by rapid sand filters during year was 5063.73 mil.gal. (Imp.). Typhoid cases since purif. of supply dropped for 20,000 houses connected to 2.7. Total length of 42″ steel main laid was 20,769′. Brackenridge Res. put into commission in Jan. '44. Augmentation of filter capac. commenced in Feb. '44. Constr. of filters will permit conversion of 4 of existing slow sand filters to clear water storage, increasing existing storage by 4.6 mil.gal. (Imp.) to total of 7.2 mil.gal. (Imp.). No constr. work carried out on Stanley R. scheme since operations ceased in Nov. '42.—*H. E. Babbitt.*

The Water Supply of Auckland, New Zealand. Anon. Wtr. & Wtr. Eng. (Br.) **48**: 515 (Sept. '45). Under Water Works Development Loan, excavation of site for service reservoir to hold 6 mil.gal. (Imp.) on Mt. Albert has been completed. Reservoir holding 1 mil.gal. (Imp.) at highest point of North Shore area in Birkenhead completed and put into service. Water gravitated from Waitakere, Nihotupu, and Huia dams, and distributed by gravitation and pumping. Total storage in reservoirs, when full, 1569 mil.gal. (Imp.). Total water consumption for year was 5367 mil.gal. (Imp.). Total length of new mains laid during year was 11¾ mi. Total length of mains now owned by city is 543 mi.—*H. E. Babbitt.*

Water Supply on Pacific Islands. John L. Sherill. Eng. News-Rec. **135**: 166 ('45). Provision of water supplies for invasion troops involved use of distn. units on shipboard, treatment in portable and mobile purif. units, sinking of shallow and deep wells, constr. of infiltration galleries in sand bars of turbid rivers, and improvisation of complete purif. plants providing for flocculation, rapid sand filtration, and pre- and post-chlorination with Ca hypochlorite.—*C.A.*